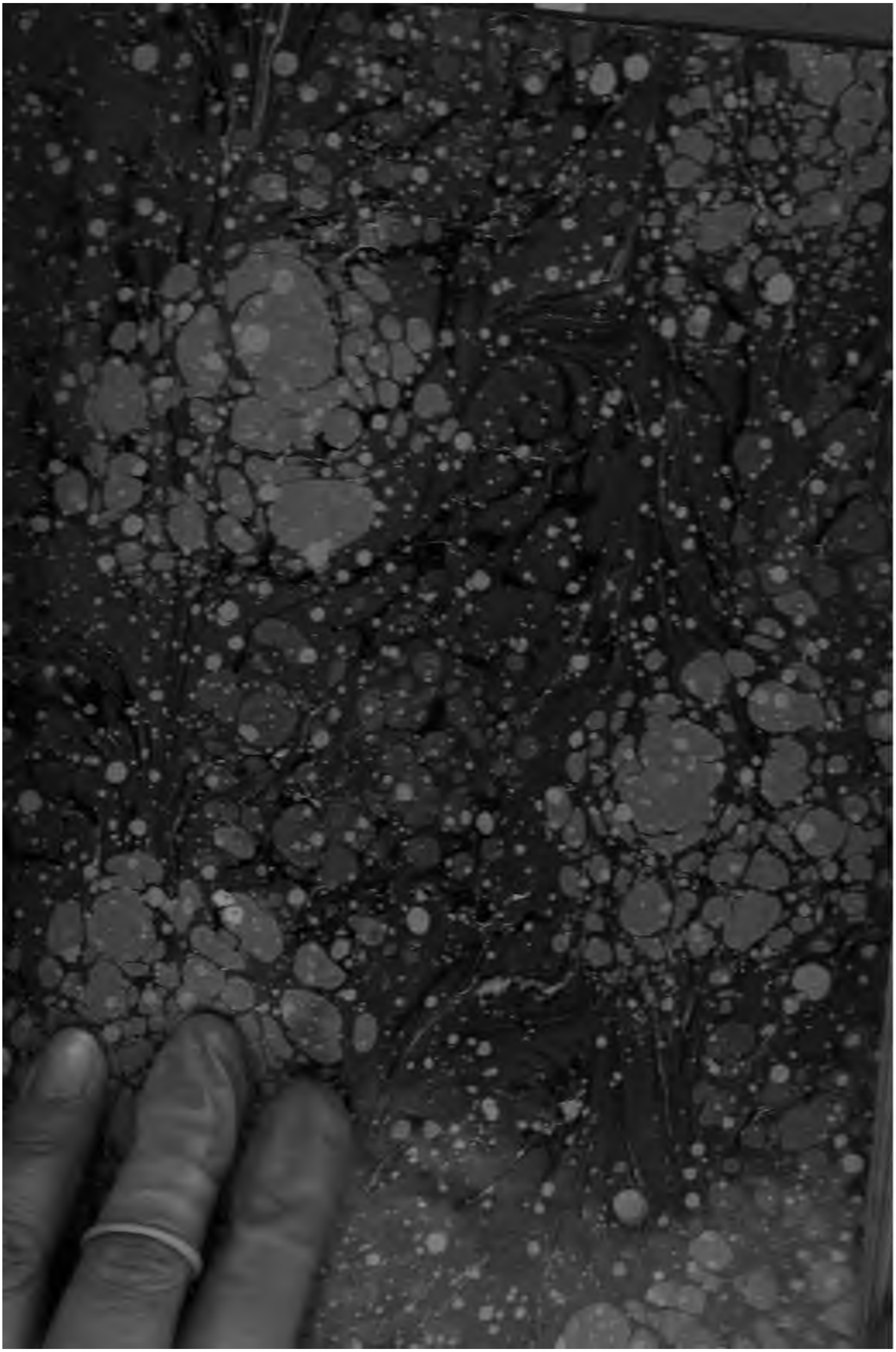

A REFERENCE HANDBOOK

OF

THE MEDICAL SCIENCES

EMBRACING THE ENTIRE RANGE OF

SCIENTIFIC AND PRACTICAL MEDICINE

AND

ALLIED SCIENCE

BY VARIOUS WRITERS

A NEW EDITION, COMPLETELY REVISED AND REWRITTEN

EDITED BY ALBERT H. BUCK, M.D.
NEW YORK CITY

VOLUME I.

ILLUSTRATED BY NUMEROUS CHROMOLITHOGRAPHS AND FOUR HUNDRED AND NINETY-EIGHT FINE HALF-TONE AND WOOD ENGRAVINGS

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MDCCCC

PREFACE.

THE first edition of the REFERENCE HANDBOOK was begun in 1884 and was completed in 1887. In 1894 it was believed that the work might be brought up to date by the publication of a supplementary volume, and accordingly such a volume was issued. During the past year the same need for alterations and additions again made itself felt, and the question then arose, Shall we issue a second supplementary volume? This question was considered very carefully in all its bearings, and the conclusion was soon reached that the publication of a second supplementary volume would be unwise owing to the fact that every new subscriber to the work would be obliged to purchase the original volumes, in which the proportion of useless text would be constantly increasing with the lapse of time. Accordingly measures were taken with a view to the complete reconstruction of the HANDBOOK. The plan of procedure which we adopted was the following: All the articles of the existing nine volumes were collected together in groups, each of which represented a special department of medical knowledge. Each such group of articles was then intrusted to a competent specialist in that particular branch, with instructions to determine which among these numerous articles were worthy of being republished (with or without revision on the part of the authors), which should be fused together and published under a single title, and which should be discarded altogether. By this process it was hoped and believed that we should learn what portions of the original edition were still valuable, and what therefore might be utilized in the reconstruction of the new. When this preliminary part of the work had been completed it was found that we could not possibly hope to retain more than one-half of the actual text of the first edition. This discovery illustrates well how many and how great are the changes which have taken place in medical knowledge during the past fifteen years.

After our expert advisers had determined to what extent we could advantageously utilize the material contained in the older edition, they undertook the further task of furnishing lists of the different topics upon which, if the entire field of medical knowledge were to be covered with some degree of completeness, articles would have to be written. The names of the men who have performed this double task and who have made it possible for me to bring the rebuilding of this great structure to a successful issue, are mentioned in the accompanying list. To one and all of them I desire to express my grateful thanks, for I recognize fully that without their efficient aid I should not be able to cope successfully with the task of deciding what shall be the contents of the new series of volumes.

Finally, I desire to acknowledge the generous manner in which the publishers have responded to all my demands upon them. When they have been convinced of its wisdom, any suggestion from myself or from one of our authors has been by them promptly adopted.

NEW YORK, September 20, 1900. ALBERT H. BUCK.

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A REFERENCE HANDBOOK

OF

THE MEDICAL SCIENCES.

Aachen.

AACHEN (Aix-la-Chapelle, Fr.), renowned for its hot sulphur springs, is an ancient Prussian town of 100,000 inhabitants, easily reached from Paris, Brussels, or Cologne, being only forty-four miles distant from the latter city. In its ancient and renowned cathedral "are the famous relics of Charles the Great, who has been honored as the discoverer of the springs and founder of the town; but thermal waters at Aachen were certainly known to the Romans," whose predilection for baths and hot springs is well known, as their elaborate remains at Bath, England, and elsewhere testify. The springs of Aachen were also visited in A.D. 756 by King Pepin the Short. The town is at an elevation of about 565 feet above sea level, is built on sandy soil, and is fairly sheltered by hills. Although the town itself has become entirely modern, its surroundings are very attractive. The climate is moderately moist. The average temperature is 54° F., and the number of rainy days 110.

The entire city is underlaid with hot springs, and within a distance of 1,316 metres the water issues from ten springs. The principal ones are the Kaiserquelle (the strongest), with a temperature of 131° F.; the Quirinusquelle, 122° F.; the Rosenquelle, 117.5° F.; and the Corneliusquelle, 114° F. The waters of the various springs are very similar in mineral constituents, differing in temperature and the amount of sulphur they contain. The Elisenbrunnen, the one most used for drinking purposes, derives its water from the Kaiserquelle.

At the larger bath establishments, which are elegantly fitted up and arranged, there are vapor baths, inhalation chambers for bronchial and laryngeal affections, and other rooms set apart for the various hydrotherapeutic processes. "The great advantage of Aix-la-Chapelle," says Dr. Baruch, "is the fact that nearly all the baths are situated in five hotels, and there is no necessity, as at Aix-les-Bains, for the patients to be carried in sedan chairs from the springs to the hotels." In the town is a Zander Institute, with Dr. Zander's medico-mechanical appliances for Swedish gymnastics. Although one can be treated at Aachen at all times, the two seasons are the summer, from April 15 to October 15, and the winter, from November to April. The accommodations are very good, and one can live in the bath establishments themselves, as has been said.

In 10,000 parts of water, the Kaiserquelle, according to the analysis of J. von Liebig, contains:

Sodium chloride	26.161
Sodium bromide	0.036
Sodium iodide	0.005
Sodium sulphide	0.095
Sodium sulphate	2.836
Potassium sulphate	1.527
Sodium carbonate	6.449
Lithium carbonate	0.029
Magnesium carbonate	0.506
Calcium carbonate	1.579
Strontium carbonate	0.002
Ferrous carbonate	0.095
Silica hydrate	0.661
Organic matter	0.769
Total	40.750
Carbonic oxide (free and partially free)	5.000

Traces of fluorine, boron, and arsenic. There is probably an organic sulphide (allyl) present in minute quantity.

The action of the Aachen thermal waters, as indeed of all thermal waters, is to increase tissue metamorphosis and thus to promote absorption of chronic inflammatory products, as in chronic rheumatism and gout; but, as Weber wisely remarks, "hot baths and hot-water drinking are likewise beneficial in these conditions, and it is not certain that the presence of small quantities of sulphur adds much to the effect of hot water"; "the same," he adds, "may be said with regard to some chronic skin diseases." In another place the same writer remarks that in other cases besides those of syphilis the reputation of the Spa is due not so much to the water as to the energetic hydrotherapeutic measures, special exercises, massage, etc., which are employed there.

On account of the chloride of sodium which they contain the waters are used in catarrhal conditions of the stomach and alimentary canal and of the bronchi. There are inhalation chambers, as has been stated above, for bronchial and laryngeal affections. The waters are also used in various affections of the abdominal viscera: in sluggish action of the bowels and stagnation in branches of the portal vein, with the resulting dyspeptic troubles; in congestion of the pelvic organs and hemorrhoidal vessels; and in enlargement of the liver. Chronic skin diseases, such as eczema and psoriasis, are treated at Aachen with more or less success, "the results obtained," as one author remarks, "doubtless partly due to the medicinal treatment." Besides chronic skin diseases, the following affections constitute the major part of those treated at Aachen: chronic rheumatism, gout, and the stiffness of joints resulting from these affections; metallic poisoning; and syphilis. Cases of the latter disease by far outnumber all the rest, for out of the 20,000 annual visitors at the Spa, 14,000 are said to come there for syphilitic treatment. "The value of these baths in this disease," says Baruch, "has produced such an afflux of syphilitics that the town has obtained quite an unenviable reputation, which prevents, it is said, purely gouty, rheumatic, and other patients from frequenting it." Weber thinks that the reputation of Aix-la-Chapelle in syphilis has been due in great part to the ordinary medicinal treatment employed there and to the attention paid to the subject by the local doctors.

Be this as it may, the success of the Aix method of treating syphilis is undoubted, and it will be of interest to repeat here the detailed account of that method which Dr. E. C. Wendt gave in the first edition of this HANDBOOK. It is, in all essential respects, as follows:—

Dr. Brandis, one of the experienced physicians of the Spa, insists on three points:

1. The body must always be adequately prepared for the absorption of the mercury, and the gray ointment must always be used carefully and in sufficient quantity. The patient is directed to take a warm bath of half an hour's duration, at a temperature of 95° F., so as to be prepared for the subsequent inunction. From this rule it may be necessary to deviate for various reasons. A very frequent cause which compels us to adopt other measures first is the fact that mercurialism, the result of previous incautiously applied mercurial treatment, is

present. After the bath the patient must be most carefully dried, and immediately, in the bathroom, rubbed with gray ointment.

During the entire treatment it is advisable to allow the patient to drink the warm waters; two or three glasses should be drunk in the morning, and a similar quantity in the evening also. In winter and cold weather the waters should be taken in bed; during the summer and on warm days, while walking about. Nevertheless, we must carefully notice whether the internal employment of the waters disturbs the digestion, whether it takes away the appetite and thus interferes with the fulfilment of a very weighty indication, namely, the nourishment of the body.

For removing debility Dr. Brandis relies not on the use of the waters, but on the abundant drinking of warm milk, a measure the merits of which have not been sufficiently appreciated.

Vapor baths, followed by copious sweating, are indicated when the mercury no longer exercises a beneficial effect upon the healing process. As a rule, patients are directed, possibly after the twentieth inunction, to take a vapor bath on three consecutive days, and then subsequently after each tenth inunction.

As to the method of performing the inunctions, Sigmund's instructions are observed. It is essential that competent rubbers do the work.

Both hands must be employed in rubbing in the ointment. The use of gloves and pads is prohibited, as they absorb too much of the ointment. Mercurial poisoning in the rubbers has not been observed. Every rubbing is to last fully twenty minutes, ten minutes for each half of the dose.

The further instructions of Sigmund are as follows:

On the first day rub both legs; on the second, both thighs; on the third, the abdomen and the breast; on the fourth, the back; and on the fifth, both arms.

Many patients, however, cannot endure the rubbing of the abdomen and breast; in such persons the rubbing is applied to the sides of the body and the nates. The daily dose varies with the body-weight and the susceptibility of the patient—between four and five grammes for adults, and from one to two grammes for children.

2. During a course of treatment the body must be maintained in good condition; the patient must take exercise in the open air, he must occupy a spacious bedroom, and he must have good food in plenty.

The treatment of the mucous membrane of the mouth is of great importance, for it is in this way that much can be done to prevent mercurial stomatitis.

Dr. Brandis employs as a mouth wash a preparation made according to the following recipe:

℞ Pulveris aluminis,
Plumbi acetatis.................... āā 30.0
Aquæ destillatæ...................... 300.0
Misce et filtra.

This solution may be used by diluting it either with pure water or with some aromatic water, in the proportion of about two dessertspoonfuls to the glass of water. The mouth must be regularly rinsed, from the beginning of treatment, ten or twelve times a day, or even oftener. Even when taking walks the patient must carry a small bottle of the liquid; and in urgent cases he must use it repeatedly, even at night. After each meal the teeth must be brushed with a mixture of prepared chalk and camphor.

Dr. Brandis states that by carrying out these measures very carefully the patient will, as a rule, escape salivation; but occasionally it happens that the physician is obliged to order a temporary suspension of the inunctions. One thing more is to be observed—namely, we may accustom even highly sensitive patients to tolerate mercury. If we know beforehand that we have to deal with such, we should begin with small doses of the mercurial ointment, and gradually increase to larger. Or if we have the misfortune to induce stomatitis, and are obliged to suspend treatment, we must postpone resuming it until all these symptoms have disappeared; we then begin again with small doses, and gradually rise to larger. A practical suggestion relates to ulcerative processes, so frequently observed in the course of syphilis. It is not always an easy matter to distinguish mercurial from syphilitic ulcerations; they both occur in the most various parts of the mucous membrane of the mouth, and may look very like each other. Above all, this holds good of those mercurial ulcerations which occasionally appear on the tonsils and on the soft palate. Here frequently only long-continued observation can decide the matter; if, however, we remain in doubt, the inunctions must be suspended; the mercurial ulcers will then heal, whereas the syphilitic ulcers will be aggravated. They also behave differently when cauterized with nitrate of silver. The mercurial sore stands an energetic cauterization very well; in fact, its healing is furthered by it; whereas the contrary is generally the case with the venereal ulcer. Increased secretion of saliva may also occasion doubt, for at times syphilitic disorders which affect the cavity of the mouth directly produce salivation. Another disagreeable result of the inunction treatment is mercurial diarrhœa. This symptom sets in suddenly; the evacuations follow one another rapidly, there is pain and tenesmus, and the stools are scanty and show mucus and blood. Treatment by opiates is indicated, while the inunctions must at once be interrupted.

Healthy persons lose in weight if subjected to mercurialization. In contradistinction to this, syphilitic patients gain in weight as soon as they enter the stage of convalescence. This applies to recent cases as well as to those of long standing.

The inunctions must be employed for a sufficiently long time. As our task consists in healing the symptoms of the disease, and as much as possible in averting relapses, the earlier the syphilitically infected person is brought under mercurial treatment, the milder will be the course of the disease.

3. Above all things, Brandis insists that we must not too soon dismiss the patient from treatment—indeed, not until all symptoms have disappeared, to the last vestige; and also, that even the slightest attacks must be energetically treated from the outset. If experience shows us, on the one hand, that inadequate treatment fails to remove completely the existing symptoms, or, after apparently curing them, is not competent to prevent later relapses, it also, on the other hand, demonstrates the fact that a long and energetic mercurial treatment will generally accomplish the desired object.

In all ordinary cases the inunctions are prolonged eight or ten days beyond the time of healing of visible lesions; the thermal baths need not be given for a longer period.

In this country the Hot Springs of Arkansas is perhaps the most renowned place for the treatment of syphilis, and so far as the waters are concerned, it offers essentially the same advantages as Aachen.

Edward O. Otis.

ABDOMEN. (ANATOMICAL.)—The abdomen is the region of the body lying between the thorax and the pelvis. It includes the abdominal wall, the abdominal cavity, and its contents, the latter comprising almost the whole of the digestive apparatus and a part of the urinary. Above, the abdominal wall is separated from the thorax by the costal arch. Below, it is continued into the pelvis and thighs, the lines of separation being the iliac crests laterally and Poupart's ligaments mesially. These superficial boundaries of the wall are not coextensive with those of the cavity, for it extends above into the vault of the diaphragm, corresponding superficially to the fourth intercostal space on the right side and the fifth on the left. Below, it passes into the pelvic cavity, the line of separation between abdomen and pelvis being the linea ilio-pectinea. Here the lower limit

is the upper surface of the levator ani and coccygeus muscles.

The form and external appearance of the abdomen vary with sex, age, and the condition of the abdominal wall and underlying organs. In infancy, as the pelvis is undeveloped and the organs in the upper part of the cavity are relatively large, the abdomen is cone-shaped, the apex of the cone being directed downward. In adult males the region is cylindrical and slightly flattened from before backward. In females it is again cone-shaped, but the apex of the cone is above, as the diameter of the lower circumference of the thorax is always less than that of the pelvis.

The ABDOMINAL WALL presents antero-lateral and posterior aspects. It differs from the walls of other cavities in being, for the most part, devoid of skeleton, which, with the elastic character of the tissues composing it, allows the cavity to vary in capacity according to the size of the contained viscera. At all times it exerts upon them a gentle pressure, supporting them, and causing the more solid to impress the softer. This pressure may be appreciated in any laparotomy wound, when the omentum and more movable intestines are retained with difficulty. The antero-lateral wall is composed of the following layers of tissue, which must be considered in detail:—

Skin,
Superficial fascia { superficial layer / deep layer,
External oblique muscle,
Internal oblique muscle,
Transversalis muscle,
Rectus muscle,
Transversalis fascia,
Properitoneal tissue,
Parietal peritoneum.

In addition to this general description, certain regions which are commonly the seat of hernia must receive especial study. These are:—

The inguinal region,
The inguino-femoral region.

The *Skin* of the abdominal wall is thin and movable except in the region of the navel, where it is attached to the underlying tissue. Corresponding to the linea alba is a furrow which indicates the space between the recti muscles. Two transverse flexion folds are usually present, one at the level of the umbilicus, a second, one inch above the pubis. This latter marks the summit of the moderately distended bladder. In pregnancy, or during the growth of large intra-abdominal tumors, the stretching of the skin may give rise to a series of longitudinal lines, called striæ gravidarum.

Superficial Fascia.—Of this there are two layers.

The superficial layer varies in thickness according to the amount of fat deposited in it. Both above and below it is continuous with the corresponding layer of tissue in adjacent regions. In the pubic region it passes into the scrotum, losing the fat, and, joining the deep layer, it assists in the formation of the dartos. At the posterior border of the scrotum it becomes continuous with the same layer of the perineum. The amount of fat deposited in this layer, together with that in the omentum and mesenteries, is the principal factor in determining the external appearance of the abdomen. Accordingly, all gradations occur, from the thin concave abdomen of the emaciated to the thick pendulous one of the obese. These variations become of importance in examinations of abdominal organs or in operations upon them. The thick wall renders the task more difficult.

The deep layer is thin and more fibrous in structure. It can be separated distinctly only in the lower half of the wall; above, it is lost in the superficial layer. Below, externally, it is connected with the iliac crests; anteriorly, it passes over Poupart's ligaments, to be attached to the fascia lata half an inch below them. In the pubic region, together with the superficial layer it passes into the scrotum to form the dartos. At the posterior border of the scrotum the layers again separate, the deeper one forming the corresponding fascia of the perineum. This latter fascia is attached on each side to the rami of the pubis and ischium, and turning around the posterior border of the transverse perineal muscles, it becomes continuous with the deep perineal fascia. It is beneath this layer of tissue that urine or an infection is guided from the perineum through the scrotum upon the abdomen. The attachment of the fascia to the bony margin of the pelvis prevents the spread into the thighs on their inner sides, while the attachment to the fascia lata prevents a similar spread from in front. The deep superficial fascia is separated from the aponeurosis of the external oblique by loose areolar tissue except along the linea alba, where the attachment is more intimate.

External Oblique Muscle (Figs. 1 and 2).—This, the strongest and most superficial of the abdominal muscles, arises by fleshy digitations from the eight lower ribs, interdigitating in the upper half with the serratus magnus, in the lower with the latissimus dorsi. The fibres are directed downward, forward, and inward, those from the last two ribs almost vertically downward to their insertion in the anterior two-thirds of the external lip of the iliac crest. The remaining fibres, more oblique in direction, terminate in a broad aponeurosis, which at the mid-line joins with the aponeurosis of the remaining muscles in the linea alba. The following structures in the aponeurosis of the external oblique require especial mention:—

Poupart's Ligament, formed by the thickened lower border of the aponeurosis, stretched between the anterior superior iliac spine and the pubic spine. Attached to it below is the fascia lata, which gives to the ligament an outline, convex downward. The flexor muscles of the thigh, the femoral vessels, and the anterior crural nerve pass behind the ligament in their course downward.

Gimbernat's Ligament (Fig. 5).—Reflected from the pubic end of Poupart's ligament to the linea ilio-pectinea for about three-quarters of an inch, is a triangular layer of fibrous tissue termed Gimbernat's ligament. It has upper and lower free surfaces, and a concave external border, bounding the femoral ring internally.

External Abdominal or Inguinal Ring (Fig. 2).—Situated in the lower and inner part of the aponeurosis is an oval opening, formed by the separation of the fibres composing this part of the aponeurosis from the fibres of Poupart's ligament. The long axis of the ring corresponds in direction to that of the fibres of the aponeurosis. Its base is formed by the pubic crest, its sides by the diverging fibres, which are called the pillars of the ring. The superior or internal pillar, thin and flat, is attached to the anterior surface of the symphysis pubis, while the inferior or external, thick and prismatic, essentially the inner end of Poupart's ligament, curves inward to terminate at the pubic spine. Further facts concerning the external ring will be mentioned in the special description of the inguinal region.

Intercolumnar Fascia.—Binding together the fibres of the aponeurosis above the inguinal opening is a set of fibres which arch transversely inward from the outer half of Poupart's ligament, thus closing the angular interval left between the diverging pillars. At the margins of the opening these fibres are continued over the spermatic cord and testicle as a fine fascia, the intercolumnar or spermatic fascia.

Internal Oblique Muscle (Fig. 1).—The general direction of the fibres composing this muscle is the opposite of that of the external oblique. It arises below, from the outer half or two-thirds of Poupart's ligament, from the anterior two-thirds of the middle lip of the crest of the ilium, and from the lumbar fascia in the angle between the crest of the ilium and the outer border of the erector spinæ muscle. From this origin the fibres ascend over the side of the abdomen to be disposed of as follows: the most posterior fibres pass upward to be inserted into the outer surfaces

of the three lower ribs; those from the crest anteriorly, the spine, and Poupart's ligament end in a broad aponeurosis which extends from the thorax to the pubis, and at the outer border of the rectus divides into two layers, to enclose this muscle, uniting again at the linea alba. The anterior layer is inseparably united with the aponeurosis of the external oblique, the posterior with that of the transversalis, and above with the seventh and eighth

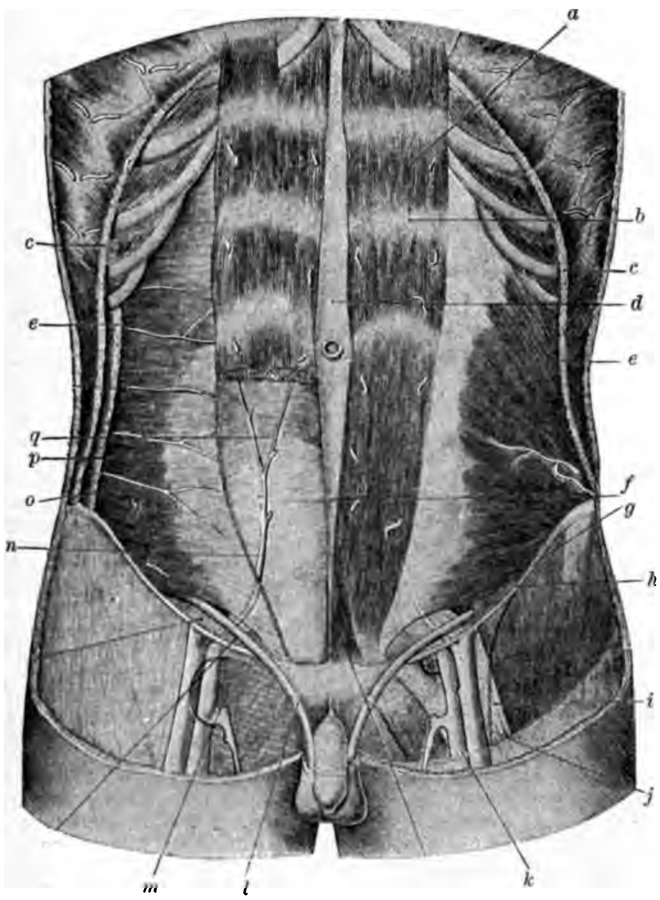


FIG. 1.—On the left side, the external oblique and the anterior layer of the rectus sheath are removed; on the right side, the external and internal oblique and the lower half of the rectus. The deep epigastric artery is shown through the wall. (Joessel.) *a*, Rectus abdominis; *b*, inscriptio tendinea; *c*, external oblique; *d*, linea alba; *e*, internal oblique; *f*, fascia transversalis; *g*, internal abdominal ring; *h*, Poupart's ligament; *i*, anterior crural nerve; *j*, femoral artery; *k*, femoral vein; *l*, spermatic cord; *m*, fossa ovalis; *n*, deep epigastric artery, shown through abdominal wall; *o*, transversalis muscle; *p*, linea semilunaris; *q*, semilunar fold of Douglas.

costal cartilages and the ensiform process. This arrangement obtains only in the upper two-thirds of the aponeurosis. In the lower third there is no division into layers, both internal oblique and transversalis passing in front of the rectus with the external oblique. The deficiency resulting in the sheath of the rectus is marked above by a semilunar edge, known as the semilunar fold of Douglas. The lowest fibres which arise from Poupart's ligament arch downward and inward, and, joining similar fibres from the transversalis, form the conjoined tendon of these two muscles, by which they are inserted into the anterior surface of the pubis and the inner part of the ilio-pectineal line, behind Gimbernat's ligament.

The *Transversalis Muscle* (Fig. 1), situated beneath the internal oblique, arises from the inner surfaces of the six lower ribs, from the transverse processes of the lumbar vertebræ by an aponeurosis, and from the anterior two-thirds of the inner lip of the crest of the ilium. Passing horizontally inward, the fibres terminate in an aponeurosis about an inch external to the border of the rectus, except at the upper extremity, where the fibres pass behind the rectus almost to the middle line. The arrangement of the aponeurosis was described with that of the internal oblique.

Rectus Abdominis Muscle (Fig. 1).—This muscle consists of vertical fibres lying within the sheath formed by the internal oblique as described above. Situated on either side of the mid-line of the abdomen, it arises from the anterior surface and crest of the pubis. Expanding and becoming thinner as it ascends, it is inserted into the cartilages of the fifth, sixth, and seventh ribs, as well as the bone of the fifth. The fibres of the muscle are interrupted by three or more tendinous intersections, inscriptiones tendineæ, placed, the first at the umbilicus, the second at the lower end of the ensiform process, the third midway between them. They are confined chiefly to its anterior fibres and are firmly united to the anterior wall of the muscle sheath. When additional transverse lines occur, they are usually incomplete and are placed below the umbilicus.

The *Linea Alba*, formed by the union of the aponeuroses of the two oblique and transverse muscles, extends in the mid-line from the ensiform process to the pubis. A little below the middle it is widened into a circular space, in the centre of which is the umbilicus. Above the umbilicus the recti muscles diverge and the linea alba broadens. Below the umbilicus the recti muscles converge and the linea becomes narrower and passes in front of the conjoined inner heads of the recti muscles to the pubis. Passing from the linea, behind the conjoined heads, is a small band of longitudinal fibres, the adminiculum lineæ albæ, which spreads out below into a triangular expansion attached to the upper border of the pubis behind the external head of the rectus. During pregnancy, or when the abdomen is distended by disease, the linea alba is much increased in breadth.

The *Linea Semilunaris*, situated along the outer border of the rectus muscle, is a curved linear depression corresponding to the narrow portion of the aponeurosis of the internal oblique, between the termination of the muscular fibres and the division of the aponeurosis to form the rectus sheath.

The *Fascia Transversalis*.—This thin layer of fascia lines the posterior surface of the transversalis muscle and is continued on to the under surface of the diaphragm. Above the umbilical line it is exceedingly thin, but below, especially in the inguinal region, it is more strongly developed and is attached to Poupart's ligament. Laterally, it is attached to the inner lip of the crest of the ilium and is continuous with the iliac fascia. An opening in the transversalis, the internal abdominal ring, will be described below.

Properitoneal Tissue and *Parietal Peritoneum*.—The properitoneal tissue is a variable layer which is situated between the transversalis fascia and the peritoneum, and is more highly developed in the inguinal regions. Farther up on the abdominal wall it is frequently absent. In this layer are situated the most important blood-vessels of the abdominal wall. The parietal peritoneum will be more especially noted below. For the most part it is separated from the fascia transversalis by the properitoneal tissue, but along the linea alba and the umbilical region the two are united.

Blood-Vessels of the Anterior Abdominal Wall.—The *Arteries* of the abdominal wall are in two sets, superficial and deep. The superficial vessels are situated in the superficial fascia. They are the superficial epigastric and the superficial circumflex iliac, derived from the femoral.

The deep set comprises the six lower intercostals, the lumbar, the deep circumflex iliac, the superior epigastric, and the deep epigastric artery. Of these, the latter requires especial description.

Arising from the distal end of the external iliac, the deep epigastric artery passes upward and inward across the rear wall of the inguinal canal to the posterior surface of the rectus; entering the sheath of the rectus it continues its course upward to anastomose with the superior epigastric, a branch of the internal mammary. It lies between the fascia transversalis and the parietal peritoneum in the properitoneal tissue. In the beginning of its course it encircles the lower and internal boundaries of the internal inguinal ring.

Two small branches arise from the deep epigastric artery: the cremasteric, which accompanies the spermatic cord, and the pubic branch, which ramifies on the superior surface of Gimbernat's ligament and the posterior surface of the pubic bone. On the surface of the abdomen the course of the artery may be indicated by a line drawn from the junction of the inner third with the outer two-thirds of Poupart's ligament, obliquely upward to the umbilicus.

The *veins* are likewise divisible into a superficial and a deep set. The superficial include the superficial epigastric, the superficial circumflex iliac, and the vena tegumentosa. The latter connects the axillary with either the superficial epigastric or the femoral veins.

The deep veins accompany the corresponding arteries and are double. They anastomose with one another, and also with the superficial veins on one side and with the portal system on the other, through the para-umbilical veins which run in the falciform ligament of the liver. In pathological states which interfere with the circulation in either the vena cava inferior or the portal system, the superficial veins may be much more prominent than is usual. In the former case, the blood current is upward, toward the umbilicus, the veins assisting in the formation of a collateral circulation. In the latter case the current is downward, away from the umbilicus, and the dilatation is due to direct stasis.

Above the umbilicus the *superficial lymphatics* empty into the axillary glands; below it, into the inguinal glands. The deep lymphatic vessels empty into the sternal glands above and into the iliac glands below.

Nerves.—The abdominal muscles are supplied by the six lower intercostal nerves: the skin of the abdomen, by cutaneous branches of the same together with the ilio-hypogastric and the ilio-inguinal from the first lumbar. The nerves are situated between the transversalis and the internal oblique, and pursue a course corresponding to the intercostal space, from which they emerge as far as the sheath of the rectus, which they pierce to become cutaneous. Laterally, between the origins of the external oblique, the latissimus dorsi, and the serratus magnus, arises a series of lateral cutaneous branches which supply the skin of the lateral aspect of the abdomen.

In this connection it is interesting to note the relationship existing between the nerve supply of the abdominal wall on the one hand, and that of the abdominal viscera and peritoneum on the other. The viscera derive their principal nerve supply from the three splanchnics, which are formed by the union of the rami communicantes of the six lower intercostals. Therefore the abdominal viscera and the abdominal walls are all connected with the same segments of the central nervous system.

In disease these nerve connections may serve to explain many of the symptoms and signs, such as reflected pains and rigid abdominal muscles in acute inflammatory states.

The surgeon is frequently called upon to open the abdominal cavity through the anterolateral wall. The incisions should be carefully planned, first, to give ample room for the necessary intra-abdominal manipulations; second, to do the least possible injury to the abdominal wall, thus reducing to a minimum the liability of a subsequent ventral hernia.

The most common line of incision is through the linea alba, this route being chosen in most pelvic operations, in those upon the intestines in general, and in many of those upon the stomach. The line is easily followed above the umbilicus, where the linea alba is broad, but below, where it is narrow, the line is followed with difficulty. In incisions above the umbilicus the position of the falciform ligament of the liver should be remembered.

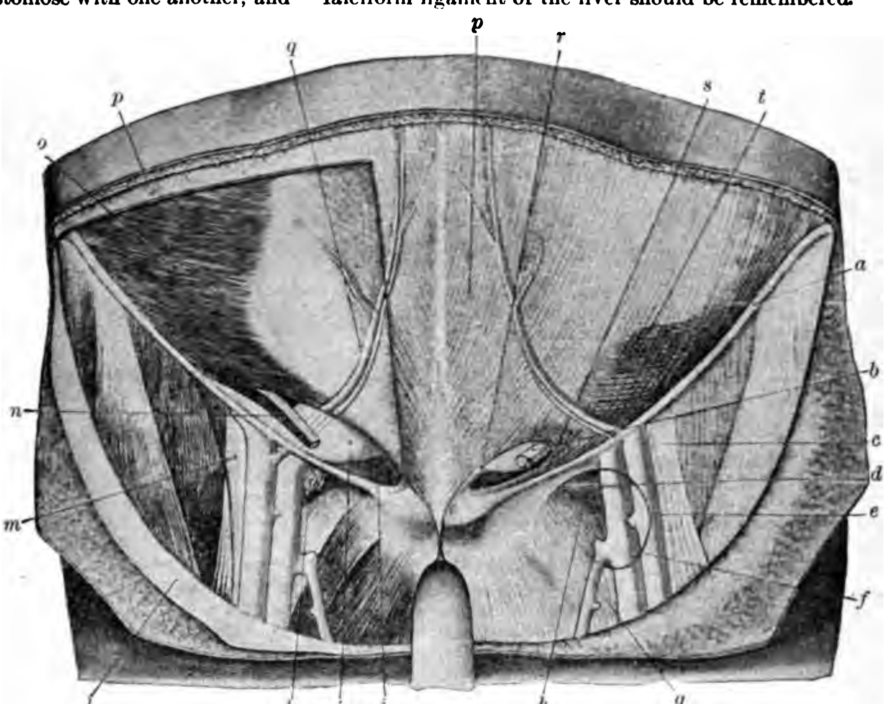


FIG. 2.–On the left side, the aponeurosis of the external oblique and the course of the deep epigastric artery on the rear surface of the abdominal wall are shown; on the right, the external oblique is removed, opening the inguinal canal. (Joessel.) *a*, Poupart's ligament; *b*, spermatic cord; *c*, anterior crural nerve; *d*, free edge of iliac portion of fascia lata; *e*, femoral artery; *f*, femoral vein; *g*, saphenous vein; *h*, fossa ovalis; *i*, reflected portion of Gimbernat's ligament; *j*, fascia transversalis; *k*, lymph gland in femoral canal; *l*, fascia lata; *m*, pubic portion of fascia lata; *n*, cremaster muscle; *o*, internal oblique; *p*, external oblique; *q*, deep epigastric vessels; *r*, superior pillar of the external ring; *s*, inferior pillar of the external ring; *t*, intercolumnar fascia.

Many surgeons prefer an incision slightly to one side of the linea,—one which opens the sheath of the rectus muscle and separates its fibres. They believe that such a wound heals more solidly than one that divides the linea alba, formed as it is by the interlacement of numerous aponeurotic layers. Certainly the linea has but one possible advantage, that is, avascularity. The rectus should be

separated only in its inner half, because of the position of the nerve trunks in its outer half. For this reason a transverse incision will do less damage than a longitudinal one in the outer half of the rectus.

In lateral incisions three points must be borne in mind: (1) The direction of muscular or aponeurotic fibres; (2) the course of nerves; (3) the course of blood-vessels.

All longitudinal or oblique incisions will divide one or more layers of muscular fibres which, in many instances, it is impossible to avoid. However, when possible the plan of McBurney should be followed—namely, that of separating each aponeurotic layer in the direction of its fibres. When the fibres of all the layers cannot be separated in this manner, it is advisable to separate those of the external oblique and divide the remaining layers. The separation of the fibres possesses many advantages—it is almost bloodless, no large nerves are injured, and the edges of the wound, instead of tending to separate, tend to approximate. It has the disadvantage of requiring a larger number of assistants and of not giving as free an opening as direct incision.

When it becomes necessary to incise the entire thickness of the abdominal wall, the incision should be planned with due regard to the nerves, remembering that they are continued forward from the intercostal spaces between the transversalis and the internal oblique. For this reason, lateral longitudinal incisions along the rectus are objectionable, division of the nerves being followed by more or less paralysis, which is an important predisposing factor in the development of a hernia.

Transverse incisions in the lower abdominal region must avoid the deep epigastric artery the course of which is indicated above. In the upper half they must avoid the superior epigastric artery, which, however, is of less importance than the deep vessel.

The INGUINAL REGION is bounded below by Poupart's ligament, internally by the median line indicated by the linea alba, and above by a horizontal line extending from the anterior superior iliac spine to the median line.

The tissue layers composing the wall are the same as those of the wall in general.

Piercing the region in an oblique direction from behind forward, downward, and inward is the spermatic cord in the male and the round ligament in the female. The track which the spermatic cord pursues in the abdominal wall is known as the inguinal canal, but it must be understood that a true canal exists only in a pathological state.

The canal presents for description an external opening, an internal opening, and four walls. As mentioned, the external opening is formed by the separation of the lower and the inner fibres of the aponeurosis of the external oblique. The ring is closed by the intercolumnar fascia, which is continued over the cord and testicle and must be teased from the cord before the ring is plainly visible. At the upper angle, it binds the columns together, thus strengthening the ring above. The external ring varies in size, depending upon the development of the intercolumnar fibres. Normally, the opening will admit the end of the finger, but this is modified by the position of the body. Flexion and external rotation of the thigh relax the opening, extension of the thigh or contraction of the abdominal muscles contracts the opening,—facts which should be remembered in the reduction of hernia by taxis. In corpulent persons and in women it is sometimes difficult to locate the ring, but it should be remembered that it is immediately above and external to the spine of the pubis. When the spine cannot be located, the tendon of the adductor longus will serve as a guide, as it lies immediately beneath the pubic spine and can in all cases be easily recognized.

The *internal abdominal ring* is situated half an inch above the middle of Poupart's ligament. Here, on the posterior surface of the transversalis fascia, the spermatic cord enters the inguinal canal, being invested throughout its entire length by a process of the fascia known as the processus vaginalis fasciæ transversalis or the infundibuliform fascia. Thus it is seen that the transversalis fascia is not perforated by the cord, but is pushed forward as an investing membrane.

The anterior wall of the canal is formed by the aponeurosis of the external oblique, the fibres of which are here crossed by the intercolumnar fibres.

The posterior wall of the canal is composed of the aponeurosis of the internal oblique and the transversalis, and of the fascia transversalis. It is divisible into two parts: a lateral, formed by the transversalis fascia, and an inner, formed by the conjoined tendon of the internal oblique and the transversalis.

The upper wall of the canal is bounded by the lower fibres of the internal oblique and the transversalis. When the origin of these muscles from Poupart's ligament extends far inward, the cord runs for a short distance between them before taking its usual position in the canal. From the lower border of the internal oblique a series of loops of muscular fibres connected by fine fascia is again prolonged over the cord. The fibres form the cremasteric muscle and the connecting fascia is the cremasteric fascia.

The lower wall or floor of the canal is Poupart's ligament. The subserous fatty tissue in this region is well developed and forms one of the layers investing a hernia.

Rear View of the Anterior Abdominal Wall in the Inguinal Region.

The parietal peritoneum covering this region of the abdominal wall is thick and freely movable. It presents a median and two lateral longitudinal folds separating as many depressions. The median fold, extending from the summit of the bladder to the umbilicus, is caused by the urachus and is known as the plica urachi. On either side of it lies the internal inguinal fossa. Of the two lateral folds the median is formed by the lateral ligament of the bladder, the obliterated hypogastric artery of the fœtus. It is known as the plica hypogastrica, and separates the internal inguinal fossa from a second, the middle inguinal fossa. The external of the lateral folds corresponds to the deep epigastric artery, and separates the middle inguinal fossa from a third, the external fossa. This fold is the plica epigastrica.

In the floor of the external inguinal fossa is situated the internal abdominal ring bounded internally by the deep epigastric artery. The floor of the middle inguinal fossa is the posterior wall of the inguinal canal. The floor of the internal inguinal fossa corresponds to a point in the abdominal wall immediately external to the outer border of the rectus muscle.

The floor of each fossa may be the exit of one of the varieties of inguinal hernia. The most important landmark of the above is the plica epigastrica, formed by the deep epigastric artery separating the external from the middle inguinal fossa. Two forms of inguinal hernia are described according to their relation to the deep epigastric artery.

Thus, a hernia emerging through the external inguinal fossa is an oblique or external inguinal hernia. It travels the entire length of the inguinal canal, and the neck of the hernial sac lies external to the deep epigastric artery.

A hernia emerging through the middle or internal inguinal fossa is an internal or direct inguinal hernia. Instead of traversing the entire length of the canal, it passes through the lower portion only, to emerge at the external ring. The deep epigastric artery is external to the neck of the sac. A hernia emerging through the internal inguinal fossa is rare and is described by Joessel as an internal oblique inguinal hernia. Quain, however, dismisses this variety with the simple statement that it is rare, and reserves the term internal oblique inguinal hernia for those cases of internal hernia which emerge between the conjoined tendon and the deep epigastric artery, and so traverse a considerable portion of the inguinal canal before reaching the external ring.

Abdomen.

External or oblique inguinal hernia may be congenital or acquired. In describing the congenital variety, it is necessary to state that the testicle in its descent from the abdomen into the scrotum is accompanied by a pouch of peritoneum which, about the time of birth, is separated by the adhesion of its walls from the general peritoneal cavity. The obliteration extends normally from the internal abdominal ring to the epididymis, the lower portion of the pouch remaining as the tunica vaginalis testis, the upper portion being gradually converted into a fibrous cord. However, the obliteration may fail wholly or in part. Thus the pouch may be obliterated only at the internal ring or immediately above the testicle, or it may remain in complete communication with the general peritoneal cavity. When the latter condition obtains, it is an easy matter for a loop of intestine to enter the processus vaginalis peritonei and so form a hernia. Such a hernia usually develops before or soon after birth, and is distinguished by the fact that the hernial contents are in direct relation with the testicle, and that the hernial sac is a preformed one. Again, such a hernia first shows itself in more adult age and may be suspected in rapidly developing cases. Thus it is seen that the term congenital applies rather to the conditions existing than to the time of life at which the hernia appears. Should the congenital hernia reach the scrotum, it passes below the testicle, surrounding it so that it is necessary to examine carefully in order to find this organ. This may serve to differentiate between congenital and acquired hernia. Should the obliteration fail in the upper portion of the processus vaginalis peritonei, but below form a normal tunica vaginalis, then the conditions are present which allow the development of a variety of hernia described as hernia into the funicular process. It resembles the congenital form in all particulars except in that of coming into direct contact with the testicle.

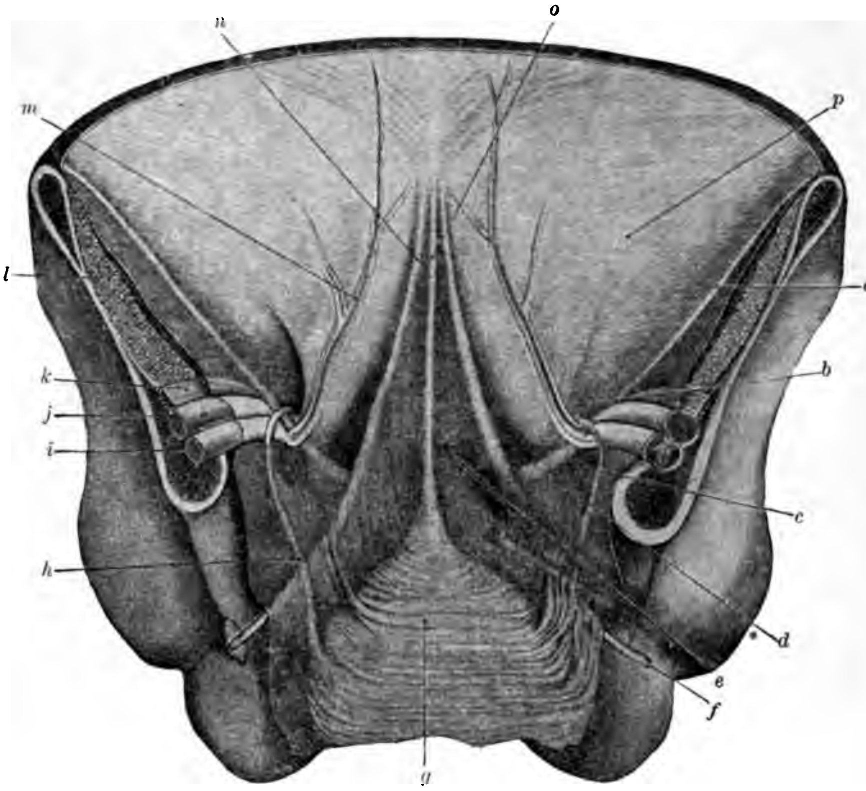


FIG. 3.—Rear View of the Anterior Abdominal Wall in the Inguinal Region. (Joessel.) *a*, Poupart's ligament; *b*, external inguinal fossa; *c*, femoral fossa; *d*, middle inguinal fossa; *e*, internal inguinal fossa; *f*, umbilical artery; *g*, bladder; *h*, vas deferens; *i*, external iliac vein; *j*, external iliac artery; *k*, anterior crural nerve; *l*, iliac muscle; *m*, plica epigastrica; *n*, plica hypogastrica; *o*, plica urachi; *p*, peritoneum.

In early childhood the inguinal canal pursues a very direct course through the abdominal wall, but as development proceeds, the pelvis widens and the canal acquires an oblique course, the internal ring receding from the external. This change in the direction of the canal may be followed by spontaneous healing of the hernia.

Acquired External Inguinal Hernia.—This variety, not having a congenital sac, provides itself with one from the parietal peritoneum. Entering the internal opening, it passes slowly along the canal to the external opening and follows the cord into the scrotum, being always separated from the testicle by its own sac and the outer layer of the tunica vaginalis. Such a hernia is of slow development and may remain for a long time within the canal before emerging from the outer opening and passing into the scrotum. During the first stages the canal retains its obliquity. As the hernia increases in size and weight the internal ring approaches the external, so that the sac passes almost directly through the abdominal wall. However, the neck of the sac is still encircled on its inner side by the deep epigastric artery. As the hernia traverses the inguinal canal it is invested by the coverings given to the spermatic cord from the several layers of the abdominal wall. These coverings are: (1) skin, and superficial fascia; (2) fascia propria, composed of, first, intercolumnar fascia; second, cremasteric muscle and fascia; (3) infundibuliform fascia; (4) the properitoneal tissue and peritoneum composing the hernial sac. In congenital hernia this is the processus vaginalis peritonei, and may be distinguished from the acquired peritoneal coat by its relation to the testicle and its firm adherence to the fascia propria. The acquired sac is easily separated from the fascia propria, while the congenital is separated with difficulty. The acquired hernial sac, like the congenital, lies directly in front of and in contact with the vessels of the spermatic cord, but does not pass below the testicle.

Two additional forms of acquired external inguinal hernia are described, and though both are associated with incomplete obliteration of the processus vaginalis peritonei, they are not provided with a congenital sac. The first is the infantile variety, in which the processus vaginalis peritonei is obliterated only at the internal ring, leaving a large tunica vaginalis testis, behind which the newly formed hernial sac descends.

In the second form, that of encysted hernia, the condition of the processus vaginalis peritonei is the same; but the septum which is undergoing obliteration yields, and, passing down into the tunica vaginalis testis, invests the new sac. In a dissection of the first, three layers of peritoneum must be divided, in a dissection of the latter only two, before the hernial contents are exposed.

Internal hernia is of much less frequent occurrence and differs from the oblique variety, (1) in passing through the abdominal wall in the floor of the middle or internal in-

guinal fossa, and consequently always lying on the inner side of the deep epigastric artery; (2) in not passing along the entire canal; (3) in external appearance, being smaller and more globular in form; (4) in being situated over the os pubis and not in the course of the inguinal canal. The most valuable differential point is

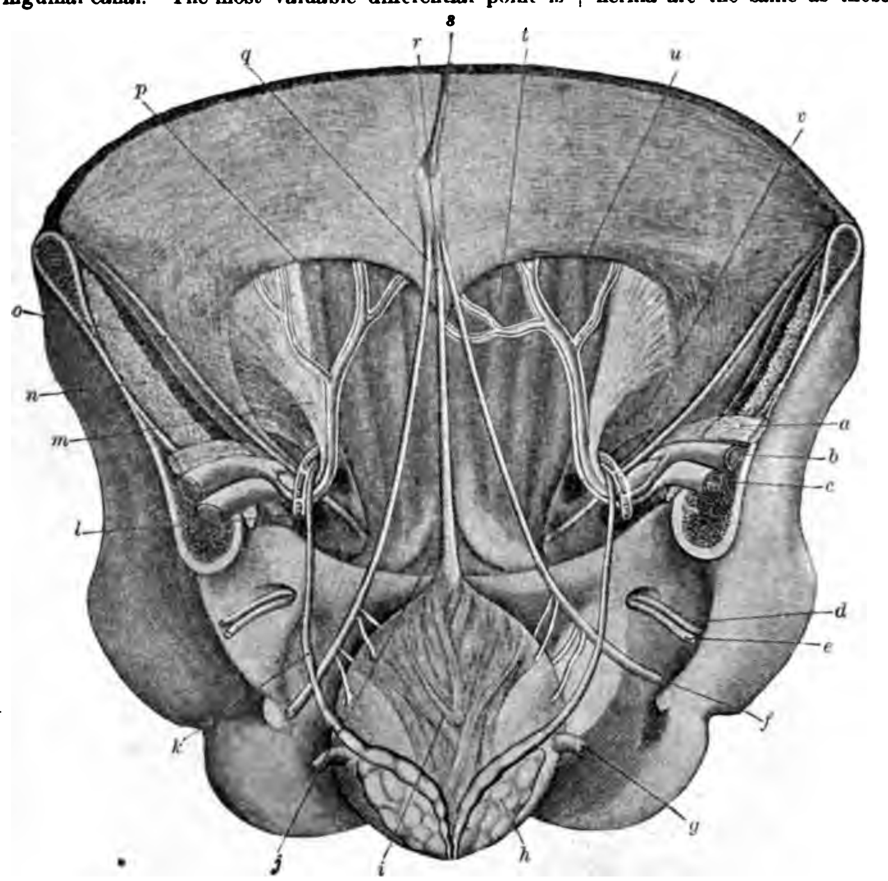


FIG. 4.—Rear View of Anterior Abdominal Wall, the Peritoneum having been Removed. (Joessel.) *a*, Anterior crural nerve; *b*, external iliac artery; *c*, external iliac vein; *d*, obturator artery; *e*, obturator nerve; *f*, umbilical artery; *g*, ureter; *h*, seminal vesicle; *i*, bladder; *j*, adminiculum lineæ albæ; *k*, vas deferens; *l*, spermatic vessels; *m*, transversalis fascia; *n*, iliacus; *o*, Poupart's ligament; *p*, semilunar fold of Douglas; *q*, obliterated umbilical artery; *r*, urachus; *s*, suspensory ligament of liver; *t*, rectus muscle; *u*, deep epigastric vessels; *v*, internal abdominal ring.

the position of the deep epigastric artery. The floor of the middle inguinal fossa is the rear wall of the inguinal canal. It is divisible into two parts: An inner part, the conjoined tendon of the internal oblique and transversalis; an outer part, the transversalis fascia. The conjoined tendon varies greatly in its development. In many cases it is slight and scarcely discernible, while in others it is strongly developed, especially in its deeper portion which is derived from the transversalis muscle, and which may bound the canal as far outward as the internal ring.

There are two forms of internal hernia which pass out through the middle fossa. The first and most common form protrudes in the inner part of the fossa, either separating or pushing before it the conjoined tendon. It traverses only the lower end of the canal, to emerge at the external ring. The coverings of this variety, from within outward, are the peritoneum and subperitoneal tissue, the fascia transversalis, and the conjoined tendon, except in those cases in which the sac passes between the fibres of the tendon, the intercolumnar fascia, the superficial fascia, and the skin. The spermatic cord, placed behind and on the outer side, is not in contact with the sac, the cremasteric and the infundibuliform fascia being interposed.

The second form of internal hernia passes into the inguinal canal through the outer portion of the rear wall, and lies between the conjoined tendon internally and the deep epigastric externally. It passes for a considerable distance along the canal, which gives it a certain degree of obliquity. The coverings of this hernia are the same as those of the first variety, with the exception of the conjoined tendon, which is replaced by a layer derived from the cremasteric fascia.

The INGUINO-FEMORAL REGION.—Upon removing the skin of the inguino-femoral region the superficial fascia of the thigh is exposed, ascending as a continuous layer upon the abdomen, descending upon the thighs, and internally passing into the dartos of the scrotum and the superficial fascia of the perineum. A deep layer of superficial fascia, thin and membranous, can also be distinguished. It is this layer which is attached to the margins of the saphenous opening, closing it and receiving in this locality the special name of cribriform fascia. Between the two layers are the superficial blood-vessels and the lymphatics of the thigh.

The deep fascia of the thigh, the fascia lata, strong and aponeurotic, concerns us only in its anterior and upper regions, where it is described as consisting of two portions, the iliac and the pubic. The iliac portion, attached throughout to Poupart's ligament, lies in front of the femoral sheath, and, at the inner end of Poupart's ligament, terminates in a free edge, which, passing downward and outward and then inward, in the angle between the internal saphenous and femoral veins, becomes continuous with the pubic portion. The pubic portion, continued upward behind the femoral sheath to which it is attached, ends at the linea ilio-pectinea.

Thus is formed the saphenous opening through which the internal saphenous vein passes to join the femoral vein. Its upper extremity lies about an inch external to the pubic spine. Its vertical diameter is about an inch and a half or two inches. Only the outer side of the opening is well marked, where the free edge of the iliac portion of the fascia forms a distinct falciform border, ending above and below in superior and inferior cornua. On the inner side, the pubic portion does not form a well-marked edge, but, after covering the pectineus muscle, passes upward behind the femoral sheath to which it is connected, to the linea ilio-pectinea where it is continuous with the iliac fascia. The deep layer of the superficial fascia is attached to the margin of the opening which it closes, and, because it is perforated by the internal saphenous vein and numerous small arteries and veins, is known as the cribriform fascia.

Poupart's Ligament.—The defect in the anterior wall of the pelvis between the anterior superior spine of the ilium and the spine of the pubis is bridged over by

Poupart's ligament. The space between the ligament and the pelvic bones serves for the passage of certain structures from the abdomen into the thigh, and is divided into three compartments by the fasciæ investing them.

The first or iliac compartment, situated externally, is formed anteriorly by Poupart's ligament and the iliac fascia, posteriorly by the ilium, and internally is separated from the second or pectineal compartment by an intermuscular septum. This compartment transmits the ilio-psoas muscle and anterior crural nerve.

The second or pectineal compartment, lodging the upper end of the pectineus muscle, does not communicate with the abdomen, but corresponds to the space between the pubic portion of the fascia lata and the pectineal surface of the os pubis.

The third or vascular compartment is the most important. It is situated in front of the other two, being bounded anteriorly by Poupart's ligament, and posteriorly by the continuous iliac and pectineal fasciæ. It transmits into the thigh the external iliac vessels and the crural branch of the genito-crural nerve.

Femoral Sheath.—As the external iliac vessels become the femoral, they are enclosed within the femoral or crural sheath, which accompanies them into the thigh. The anterior wall of the sheath is derived from the transversalis fascia, the posterior wall from the iliac fascia. On the outer side of the artery the two layers are continuous and closely embrace it; but on the inner side, while they are continuous, a space is left between them and the vein. Furthermore, both the anterior and posterior walls are attached to the iliac and pubic portions of the fascia lata, respectively.

Within the sheath the artery lies external to the vein, and is separated from it by a thin septum stretched from the anterior to the posterior wall. A second septum completes, on the inner side, the compartment for the vein, and cuts off a third space, about one-half inch in length, between the vein and the inner wall of the sheath. This is the funnel-shaped crural canal, through which a femoral hernia descends. Thus each vessel has its separate compartment, and there remains a small internal compartment containing only areolar and lymphatic tissue.

The Femoral or Crural Canal.—The size of the femoral canal varies in different persons, being larger in the female than in the male. Like the external abdominal ring, the size of the femoral canal and the degree of tension of its orifices are markedly influenced by the position of the thigh. Extension, abduction, and external rotation contract the opening, while flexion, adduction, and internal rotation relax the femoral canal and its orifice; consequently this latter position should be used in the application of taxis to a femoral hernia.

The four walls of this canal will be understood from the above description. Below, it terminates beneath the saphenous opening, while above, it opens on the anterior abdominal wall by an aperture known as the femoral or crural ring. This aperture is oval, and is larger in the female; its long diameter, directed transversely, is about one-half inch.

The ring, covered by the parietal peritoneum, shows a slight depression, which, if not visible, can easily be felt. Beneath the peritoneum is a thin layer of condensed properitoneal tissue, the septum crurale, which closes the ring. The ring is bounded anteriorly by Poupart's ligament and the deep crural arch; posteriorly, by the os pubis, covered by the pectineus muscle and the pubic portion of the fascia lata; externally, by the external iliac vein. Internally to the ring are the sharp margins of Gimbernat's ligament, the conjoined tendon, and the deep femoral arch. With the exception of the external, the boundaries of the ring are formed by very unyielding structures.

Relations. The position of the external iliac vein has been noted. The deep epigastric vessels cross the superior and external angle. A small communicating branch between the deep epigastric and obturator arteries is usually found on the superior aspect of Gimbernat's ligament.

Obturator Artery.—In two out of every five subjects, the obturator arises from the deep epigastric on one or both sides. It then turns backward into the pelvis to reach the thyroid foramen. In doing so it may pursue one of two courses: First, it may turn backward close to the external iliac vein, and will then be on the outer side of the femoral ring; second, it may first run inward, then arch backward along the free edge of Gimbernat's ligament, and will then be on the inner side of the ring. This inner position is more frequent in males than in females, though the epigastric origin on the whole is somewhat more common in females than in males.

These anomalies can be detected in a given case only by palpation of the artery through the femoral canal.

Femoral hernia is rare as compared with the inguinal variety. It occurs more frequently in females, and is al-

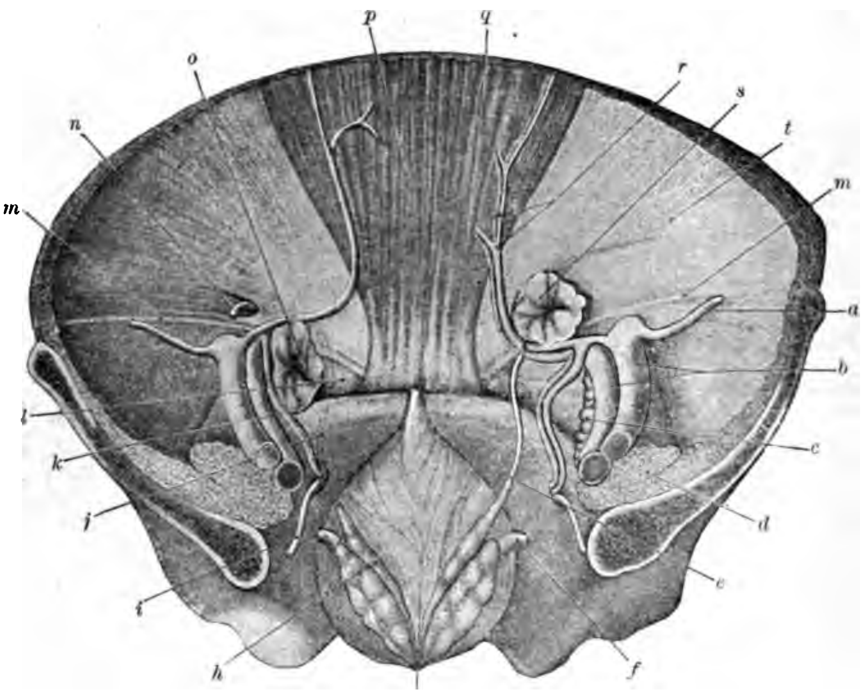


FIG. 5.—On the right side are shown the location and relations of an external inguinal hernia; on the left side, those of a femoral hernia. The obturator artery is shown arising from the deep epigastric. Its course along the free edge of Gimbernat's ligament is diagrammatically shown on the left side. (Joessel.) *a*, Deep circumflex iliac artery; *b*, external iliac artery and vein; *c*, lymphatic glands; *d*, ilio-psoas muscle; *e*, vas deferens; *f*, ureter; *g*, bladder; *h*, seminal vesicles; *i*, obturator nerve; *j*, abnormal obturator artery, internal to sac of femoral hernia; *k*, abnormal obturator artery, external to neck of femoral hernia; *l*, Gimbernat's ligament; *m*, Poupart's ligament; *n*, internal abdominal ring; *o*, sac of a femoral hernia; *p*, rectus muscle; *q*, upper border of pubis; *r*, deep epigastric vessels; *s*, sac of an external inguinal hernia; *t*, transversalis fascia.

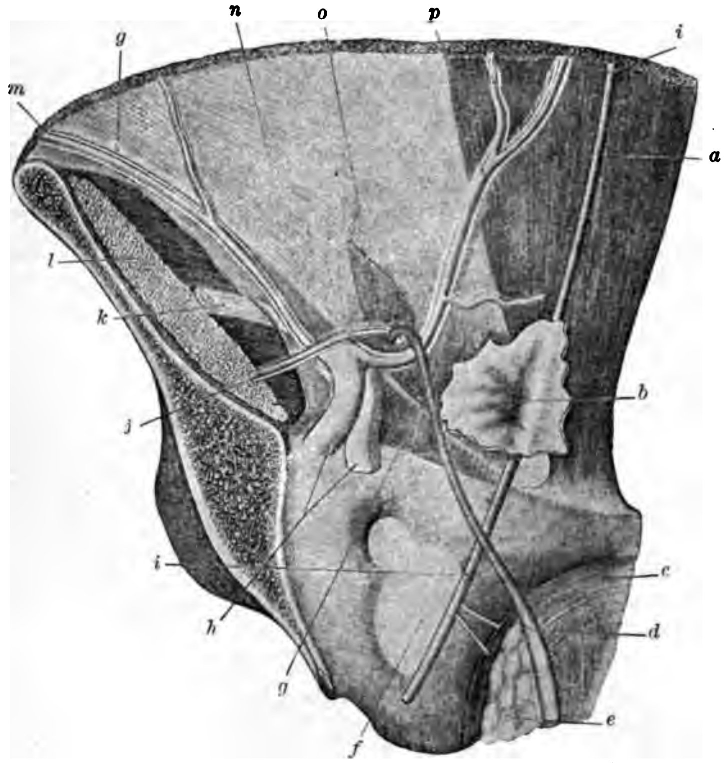


FIG. 6.—Rear View of Internal Inguinal Hernia. (Joessel.) *a*, Rectus; *b*, sac of internal inguinal hernia; *c*, bladder; *d*, vas deferens; *e*, seminal vesicle; *f*, obturator foramen; *g*, Poupart's ligament; *h*, external iliac artery and vein; *i*, obliterated umbilical artery; *j*, spermatic vessels; *k*, crural nerve; *l*, iliac muscle; *m*, deep circumflex iliac vessels; *n*, transversalis fascia; *o*, internal abdominal ring; *p*, deep epigastric vessels.

ways acquired. Entering through the femoral ring, it passes vertically downward along the femoral canal as far as the end, carrying before it a sac of peritoneum and the septum crurale. Having reached this point, the hernia turns forward through the saphenous opening, where it derives a covering from the cribriform fascia, and then ascends beneath the superficial fascia of the groin as far as, or above, Poupart's ligament. The fascia propria is composed of the septum crurale and the femoral sheath, but at times, instead of distending the sheath, it passes through an opening in it.

Within the canal the hernia is small, as it is surrounded by unyielding structures; but having passed the saphenous opening, it rapidly enlarges. The direction of a femoral hernia and the position of the body should be borne in mind during attempts at reduction by taxis. Thus the lower limb should be flexed, adducted, and rotated inward. The pressure should be first downward, then backward, and finally upward.

A femoral hernia may be strangulated at any part of the canal or at the saphenous opening, the most frequent point being the femoral ring. In all cases the stricture may be safely divided in an upward direction. At the femoral ring, the least damage will be done by dividing Gimbernat's ligament, except in cases of anomalous obturator artery.

The coverings of a femoral hernia, from without inward, are the skin, the superficial fascia, the cribriform fascia, the fascia propria, consisting of the femoral sheath and the septum crurale, and the peritoneum.

The Posterior Abdominal Wall. The posterior abdominal wall is of simpler construction and of less extent than the antero-lateral. In its centre is the portion of the spinal column composed of the five lumbar vertebræ with their connecting ligaments and cartilages. On each side are arranged the muscles—ilio-psoas, quadratus lumborum, and erector spinæ—enclosed within sheaths of fascia, that of the ilio-psoas muscle being of especial importance. This fascia is attached to the spinal column about the origin of the muscle; to the ligamentum arcuatum internum and to the anterior layer of the lumbar aponeurosis along the outer border of the muscle. Below, it firmly binds the iliac portion of the muscle into the false pelvis, being attached about its entire circumference, with the exception of the space where it passes beneath Poupart's ligament to form the posterior wall of the femoral sheath. It follows the tendon of the ilio-psoas to its insertion, and ends by blending with the fascia lata. Beneath this fascia collections of pus resulting from caries of the spine or of the ilium may be guided into the thigh, to appear just below the groin on the outer side of the femoral vessels. These collections of purulent fluid should be distinguished from those situated beneath the transversalis fascia or in the subperitoneal tissue. In the first instance, the pus can spread no farther backward than the outer edge of the psoas, and no farther downward than the iliac crest and Poupart's ligament; internally, it is arrested at the mid-line. In the second instance, an abscess is in close contact with the cæcum or sigmoid flexure, and may open into one of them; or it may follow the iliac blood-vessels into the thigh. In any case the typi-

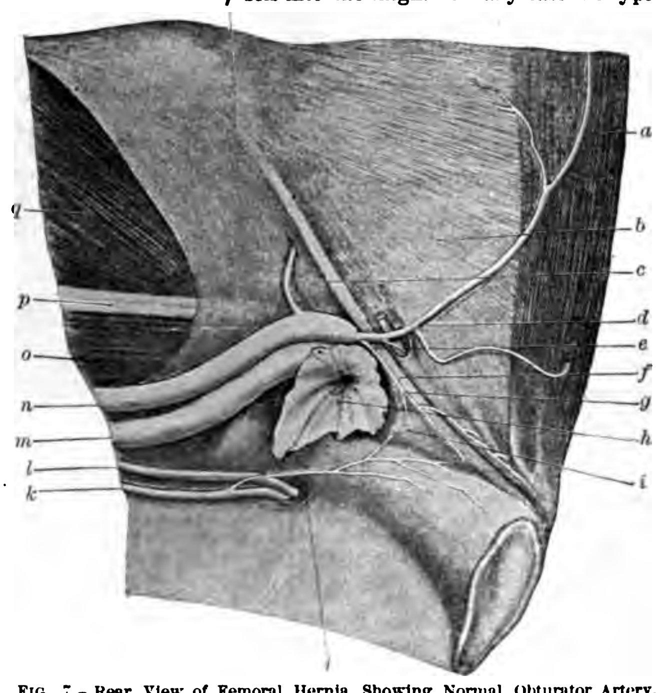


FIG. 7.—Rear View of Femoral Hernia, Showing Normal Obturator Artery. (Joessel.) *a*, Rectus muscle; *b*, transversalis fascia; *c*, deep circumflex iliac artery; *d*, deep epigastric artery; *e*, cremasteric artery; *f*, Poupart's ligament; *g*, pubic branch of deep epigastric; *h*, hernial sac; *i*, Gimbernat's ligament; *j*, pubic branch of obturator artery; *k*, normal obturator artery; *l*, obturator nerve; *m*, external iliac vein; *n*, external iliac artery; *o*, psoas muscle; *p*, anterior crural nerve; *q*, iliac muscle; *r*, iliac fascia.

cal picture may be lost should an abscess penetrate the layer of fascia beneath which it originally developed.

The incisions through the posterior abdominal wall are made to expose the kidney and colon. They are noted under the descriptions of these organs.

Abdominal Cavity and Contents.—The abdominal cavity is arbitrarily divided into nine regions by two horizontal and two vertical lines. The superior horizontal line extends between the cartilaginous ends of the tenth ribs, the inferior between the anterior superior iliac spines. These two lines divide the cavity into three zones, epigastric, mesogastric, and hypogastric, each of which is subdivided into three regions by vertical lines passing upward from the ilio-pectineal eminences to the higher horizontal line. The epigastric zone contains, in order, the right hypochondrium, epigastrium, and left hypochondrium. The mesogastric zone contains the right lumbar, umbilical, and left lumbar regions. The hypogastric zone contains the right iliac, hypogastric, and left iliac regions.

The viscera situated in each region are shown in the following table:

Right Hypochondrium.	*Epigastrium.*	*Left Hypochondrium.*
Liver. Right kidney. Hepatic flexure. Colon.	Liver. Stomach. Gall bladder. Duodenum. Pancreas.	Stomach. Spleen. Left kidney. Splenic flexure. Colon.
Right Lumbar.	***Umbilical.***	***Left Lumbar.***
Right kidney. Ascending colon. Ileum.	Transverse colon. Duodenum and small intestines. Great omentum.	Small part of left kidney. Descending colon. Small intestines.
Right Iliac.	***Hypogastric.***	***Left Iliac.***
Cæcum. Appendix. Last coil of ileum.	Small intestines. Bladder in children. Distended bladder in adults. Pregnant uterus. Sigmoid colon.	Sigmoid colon. Small intestines.

Liver.—The liver occupies the right hypochondriac region and part of the epigastric, and extends into the left hypochondriac region as far as the mammillary line; at times it descends into the right lumbar region. With the exception of a small part of the right and left lobes, which come in contact with the anterior abdominal wall in the subcostal angle, it lies behind the ribs and costal cartilages.

Surface Outline. The outline of the liver may be indicated on the surface of the body as follows: Superiorly, a line beginning in the mammillary line in the fifth left intercostal space, extending toward the right, through the lower end of the sternum, gradually rising to the fourth right interspace just inside the nipple line, then sloping downward behind the fifth and sixth ribs, where the superior surface is continuous with the right surface. Inferiorly, beginning on the right side at the upper border of the third lumbar vertebra, the line runs directly to the costal arch, which it follows as far upward as the tip of the ninth costal cartilage. Here it crosses the subcostal angle to the eighth left cartilage, then gradually rises to terminate at the beginning of the superior line. The right surface, lying behind the seventh, eighth, ninth, and tenth ribs, is separated from them only by the thin edge of the lung, the diaphragm, and the pleura. It is thus apparent that the lower border is most accessible to examination, and especially that part of it which lies across the subcostal angle. Here it usually reaches a point midway between the end of the sternum and the umbilicus. When the lower border in the remainder of its extent is easily palpable, the liver is either displaced or enlarged. The superior extent can be determined only by percussion, but the line of absolute dulness does not correspond to the line above given, for the reason that the anterior, right, and posterior surfaces are considerably overlapped by the lower edge of the lung. This line in the mid-line falls at the end of the sternum, in the right nipple line at the sixth rib, in the mid-axillary line at the eighth rib, and in the scapular line at the tenth rib. When the border of the liver can be palpated this method of determining its lower limit will be found more accurate than that by means of percussion.

Relations. The liver presents superior, anterior, posterior, inferior, and right surfaces.

The *superior surface* is accurately moulded to the diaphragm, which separates it from the pleuræ, lungs, pericardium, and heart.

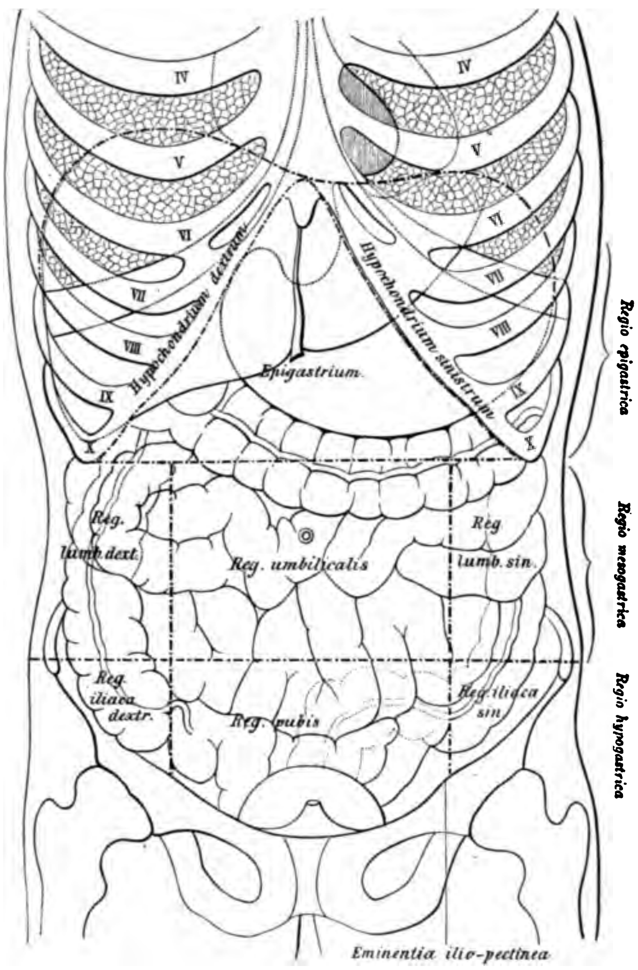


Fig. 8.—Regions of the Abdomen. Anterior view. (Joessel.)

The *anterior surface*, also in contact with the diaphragm, with the exception of the small region coming in contact with the abdominal wall in the subcostal angle, lies behind the fifth to the ninth costal cartilages and adjacent portions of the ribs. In its upper part it is overlapped by the lower margin of the lung.

The *posterior surface*, also in contact with the diaphragm and overlapped by the lung, covers in turn the right suprarenal capsule, the vena cava, the thoracic duct, and the œsophagus.

The *inferior surface* is plainly impressed by the following organs: Beginning at the right, in front, the hepatic flexure of the colon; behind, the right kidney, immediately to the left of which is the impression of the duodenum, and to the left of both the impression of the

gall bladder. The succeeding part of the liver is the quadrate lobe, lying in front of the lesser omentum. Finally, the under surface of the left lobe overlaps the lesser curvature and upper part of the anterior surface of the stomach.

The *right surface* lies internal to the seventh, eighth, ninth, tenth, and eleventh ribs, being separated from them by the diaphragm, and being overlapped above by the lung. Many clinical facts of importance can be learned by a close study of these relations. In gunshot and stab wounds of the lower part of the thoracic wall, lung, pleura, diaphragm, peritoneum, and liver may all be involved. The end of a fractured rib may penetrate the liver. Abscesses of the liver may extend through the diaphragm and open into the pleural cavity, or, when this is obliterated by adhesions, into the lung, and a bronchus. Behind, an enlargement of the liver may retard the circulation in the aorta, the vena cava, or the thoracic duct. Below, the close relations of the stomach, duodenum, and colon explain the ease with which adhesions develop between these organs, and disease spreads from one to the others.

During inspiration, the liver descends about the breadth of one intercostal space. The lower border is more easily palpable in the erect posture than in the recumbent, as in the latter it recedes somewhat behind the costal arch. These changes in position, especially the first, may serve to distinguish a tumor or swelling of the liver from one of the stomach, kidney, adrenal gland, or pancreas. The peritoneal relations of the liver are extensive and important. For the most part its surface looks into the general peritoneal cavity, and the reflections of the peritoneum from the abdominal wall and diaphragm are the principal agents in supporting, or rather suspending, the organ. A small part of its posterior surface is not visible from the greater cavity, as it looks into the lesser. This corresponds in extent to the Spigelian lobe. A second area of the posterior surface, between the layers of the right coronary ligaments, is not covered by peritoneum; it lies in contact with the diaphragm. This locality is the favorite seat of subphrenic abscesses, and here they most easily spread to the pleura and lung.

The artery of the liver is the hepatic branch of the cœliac axis. It reaches the organ between the layers of the lesser omentum, and entering at the transverse fissure its branches accompany those of the portal vein.

The portal vein, formed behind the head of the pancreas by the union of the superior mesenteric, splenic, inferior mesenteric, and the veins of the stomach, also ascends in the lesser omentum to the transverse fissure. In the substance of the liver its branches are situated within the portal spaces, *i.e.*, outside the lobules, before entering the intralobular capillaries. They are distinguished by their relatively thick walls and collapsed state on cross section. An infective thrombo-phlebitis in a distant part of the abdomen or pelvis may be followed by a metastatic abscess or abscesses in the liver, a phenomenon explained by the anatomy of the portal circulation.

The hepatic veins are remarkable for their thin walls, which, closely connected with the surrounding liver substance, stand widely open on section. Consequently a rupture or incised wound of the liver bleeds with great freedom and the bleeding has little tendency to cease spontaneously. The hepatic veins emerge on the posterior surface of the liver, entering immediately the inferior vena cava within half an inch to an inch from its termination in the right auricle. They have no valves; consequently the circulation in them is easily impeded. In some forms of valvular heart lesions,—*e.g.*, tricuspid insufficiency,—the pulsation of the heart may be transmitted through them to the liver.

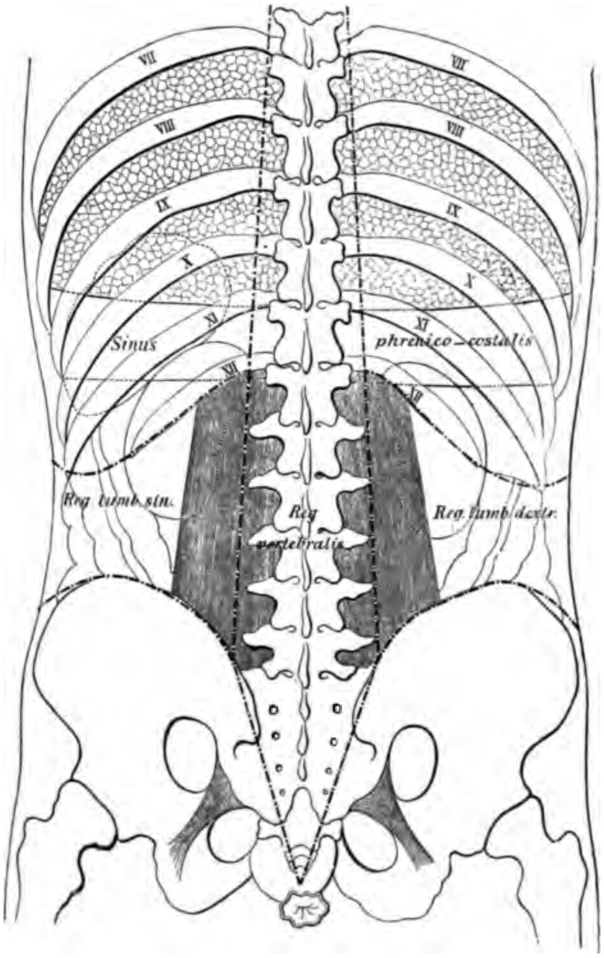
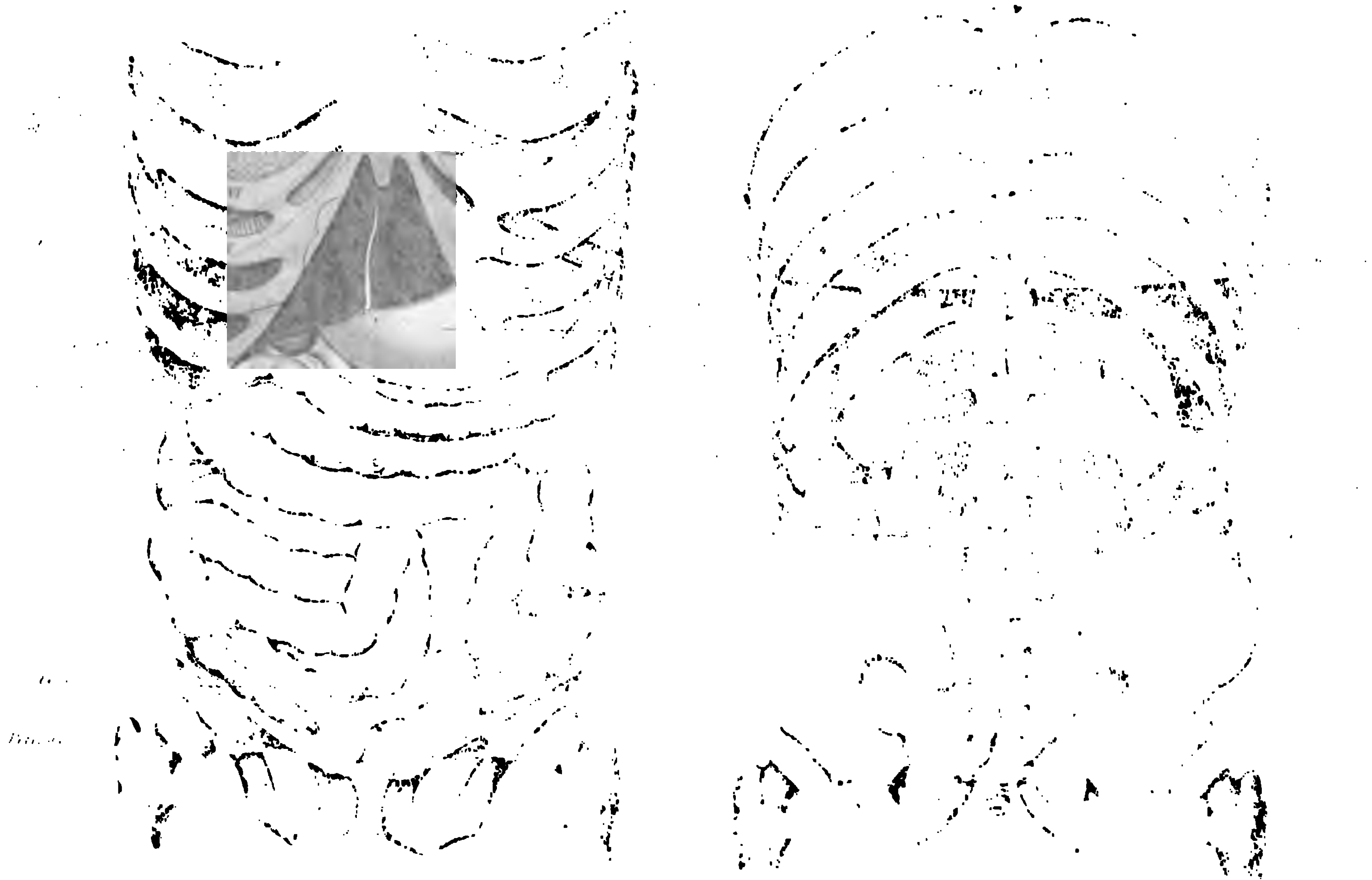


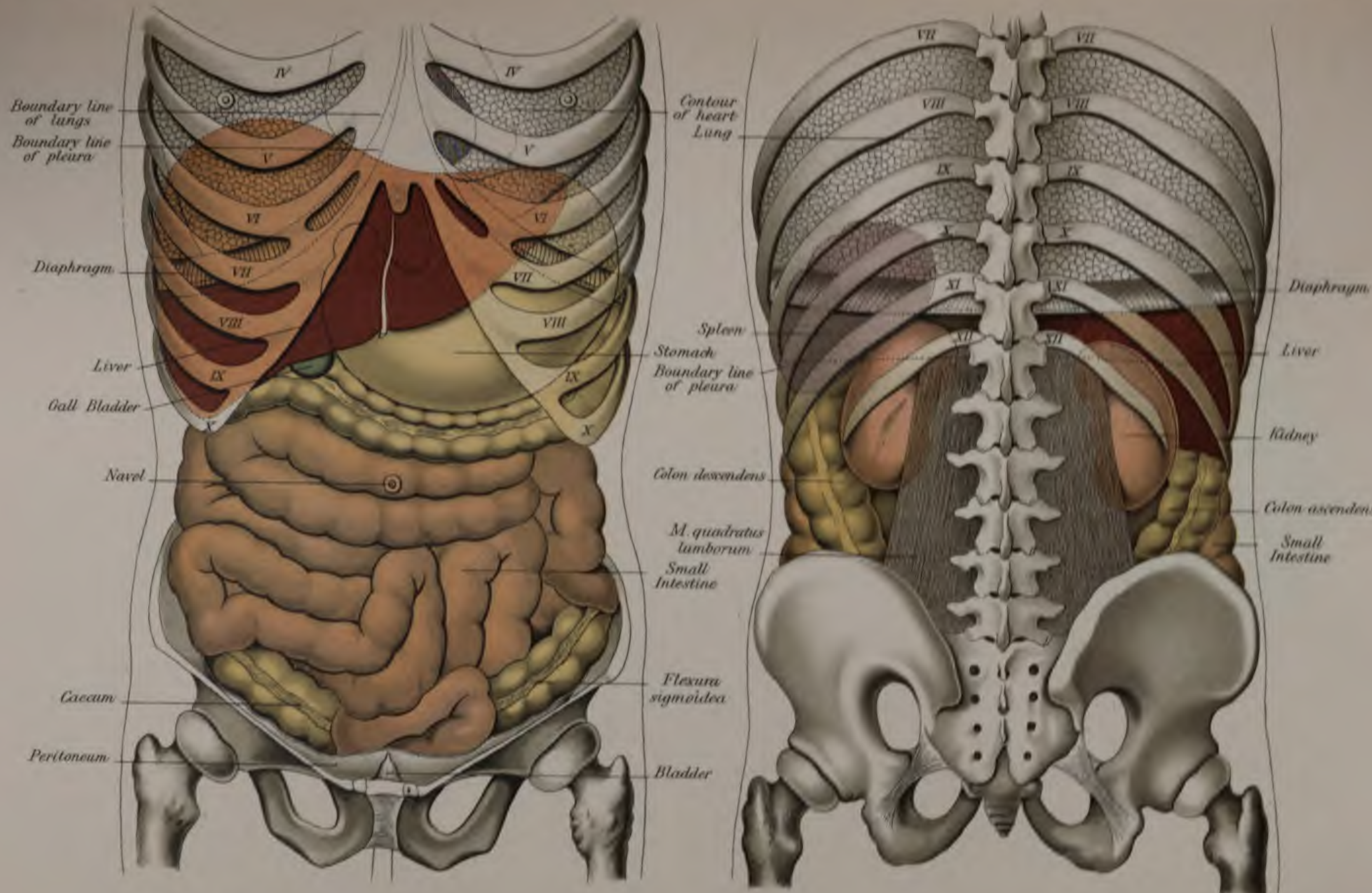
FIG. 9.—Regions of the Abdomen. Posterior view. (Joessel.)

The excretory apparatus of the liver consists of the hepatic duct, the cystic duct and gall bladder, and the common duct. The gall bladder, three or four inches in length and with a capacity of from one to two ounces, is held in position on the under surface of the liver by the peritoneum. As a rule, it is closely applied to the liver substance, lying in a distinct fossa; but it may hang free, completely invested by peritoneum and suspended by a mesentery. Its fundus projects beyond the lower border of the liver opposite the ninth costal cartilage. It is directed downward, forward, and to the right, while the neck is in the opposite direction. Immediately below it are the transverse colon, duodenum, and sometimes the pylorus of the stomach. The relation to the colon is most constant and important. An artificial opening is sometimes formed between the two organs, and through it gall stones may be passed.

The ducts are all situated between the layers of the lesser omentum, and can be easily exposed by removal of its anterior layer. The portal vein, hepatic artery, and hepatic nerves are found in the same space, but the ducts are anterior to them, and occupy the right free edge of the omentum. In making a dissection, or in an operation, the foramen of Winslow should first be located, and with the fingers of the left hand in it for a guide an exposure can be easily accomplished. The cystic duct, arising at the neck of the gall bladder, is an inch and a half in length. It is directed downward, backward, and to the left, to join the hepatic duct at an acute angle. The hepatic duct, about two inches in length, is directed downward, backward, and to the right. It arises at the liver by two main branches. The common bile duct, formed by the union of these two, continues the direction



...ont and Rear View ... of the Trunk of the B... Relations of the Abdominal and Thoracic Organs to one another. (After Joessel.)



Front and Rear Views (diagrammatic) of the Trunk of the Body, showing the Relations of the Abdominal and Thoracic Organs to one another. (After Joessel.)

of the hepatic along the right free edge of the lesser omentum on the anterior surface of the portal vein, and to the right of the hepatic artery. Approaching the duodenum, the vein tends to the left, the duct to the right. This relation of the vein to the duct is remarkably constant, but the hepatic artery and its branches are subject to frequent variations which should be guarded against. As the common duct reaches the duodenum, it passes behind its first portion, then downward, between the second portion and the head of the pancreas; or it is embedded in the latter, from which point onward it accompanies the pancreatic duct into the lower part of the second portion of the duodenum. The duodenal orifice is markedly constricted, but just proximal to it the duct is dilated, forming a well-marked diverticulum. Consequently a calculus may successfully pass the entire duct, to be arrested at the terminal orifice. To cause a jaundice, calculi must be situated in either the hepatic or the common duct, for any number may occupy the gall bladder or the cystic duct, yet give rise to few or no symptoms as long as they remain there and the gall-bladder is not infected. Not all cases of jaundice are due to gall stones. Enlarged lymphatic glands in the lesser omentum, tumors of adjacent organs, especially of the head of the pancreas, hydatids, ascaris, adhesions producing flexures of the ducts, and many other causes have been noted.

The *stomach* varies in position and relations according to the degree of distention. When empty, it lies in the left hypochondrium and left half of the epigastrium, the cardiac orifice being four or five inches posterior to the interval between the seventh left costal cartilage and the ensiform process, on a level with the eleventh or twelfth dorsal vertebra. This is the most fixed portion of the stomach, and participates only slightly in any changes of position. The pylorus is in or near the mid-line, at the level of the last dorsal or first lumbar vertebra. It looks toward the right, and is the most movable portion of the stomach. Thus a tumor of the pylorus may be found in the central or lower part of the abdomen. The anterior and posterior surfaces are separated by sharp borders, and the entire viscus recedes from the anterior abdominal wall behind the liver.

When distended, the fundus fills the left cupola of the diaphragm, impinging upon the liver and heart. The great curvature comes in contact with the anterior abdominal wall in the subcostal angle, and may enter the left lumbar and umbilical regions. Immediately below it is the transverse colon. The pylorus moves to the right as much as two or three inches, and rotates so that it is directed backward, being concealed from in front by the dilated lesser cul-de-sac.

Relations. The anterior surface is divisible into two regions: the upper and right region, which includes the pylorus and cardia, and is overlapped by the right and left lobes of the liver; and the lower and left region, which may be subdivided into two, viz., the small triangular portion in contact with the anterior abdominal wall, and above this the portion lying behind the costal arch and diaphragm. The fundus is also overlapped by the lung and pleura in the fifth and sixth intercostal spaces. Here, again, a wound may involve both thoracic and abdominal viscera. Posteriorly, the stomach is in relation with the diaphragm, spleen, left kidney and capsule, pancreas and the splenic flexure of the colon, all of which taken together form for it a concave bed. The peritoneal relations of the stomach are complicated. Its anterior surface faces the greater peritoneal cavity, but the posterior surface is concealed behind the great omentum, which hangs from its greater curvature. Furthermore, joined to the posterior surface of the omentum are the transverse colon and the mesocolon. When the omentum is raised these structures are carried with it. Only by passing the finger through the foramen of Winslow can the posterior surface of the stomach be reached. In a dissection, however, one of two routes may be chosen. The first lies between the greater curvature and the transverse colon; the second passes through the transverse mesocolon. Surgeons choose the former. A peritonitis arising from perforation of the posterior wall of the stomach, whether due to trauma or to disease, will at first involve the lesser cavity only and may be limited entirely to it. In operating for wounds of the stomach, the posterior surface should always be examined in the manner indicated. The lesser omentum is attached to the entire lesser curvature, while the gastro-splenic and greater omenta are continued from the greater curvature.

The arteries of the stomach are derived from the three branches of the cœliac axis, and reach the organ between the layers of the omenta. On the lesser curvature an arch is formed by the gastric and pyloric branches of the hepatic; on the greater, a similar arch is formed by the gastro-epiploic dextra and sinistra. From these arches transversely directed branches arise which anastomose near the centre of the surfaces. Incisions in the stomach wall are best made in the direction of the transverse branches, with the exception of the central region where the sets anastomose.

Small Intestines.—With the exception of the duodenum, the small intestines are surrounded throughout by peritoneum, and are suspended from the posterior abdominal wall by a mesentery.

The line of attachment of the mesentery extends from the left side of the second lumbar vertebra obliquely across the vertebral column, aorta, vena cava, and third portion of the duodenum to the right sacro-iliac articulation. Although this line is only six or eight inches in length, and the average width of the mesentery is eight or ten inches, it reaches at its convex intestinal edge a length of some twenty feet. The middle or lower intestinal loops have the widest mesentery and are therefore most likely to enter a hernia. Between its layers are the blood-vessels, lymphatics, and nerves of the intestine.

The duodenum is for the most part situated behind the peritoneum, a position which it acquired when the large intestine of the embryo crossed the small. Up to this time it possessed a mesentery, which then fused with the posterior body wall. The first portion of the duodenum is movable except at its distal end. With an empty stomach it is directed transversely; with a distended stomach, antero-posteriorly. Above, it is in relation with the liver and gall bladder; below, with the pancreas; behind, with the portal vein and common bile duct. Beneath the neck of the gall bladder, at a point opposite the first lumbar vertebra, it turns downward as far as the fourth vertebra, in front of the right kidney and vena cava, being crossed anteriorly by the meso-colon, above and below which it is covered by visceral peritoneum. Internally is the head of the pancreas, whose duct opens with the bile duct into the lower portion of the intestine. This constitutes the second portion, at the end of which the duodenum turns to the left across the spinal column and great vessels to ascend a short distance and end in the jejunum opposite the first or second lumbar vertebra. Note its relations to surrounding organs in connection with the spread of disease. It may be involved and the peritoneal cavity may escape. Wounds are serious because of its inaccessibility and its fixed position. With the exception of the first part, it cannot be raised into a laparotomy wound. Its arteries, forming an arch within the concavity, may be opened in a duodenal ulcer and may allow a fatal hemorrhage.

The jejunum and ileum include the remainder of the small intestines—two-fifths jejunum, three-fifths ileum. Although there is no distinct line separating them, each has distinctive characteristics. The walls of the jejunum are thicker and more vascular, the valvulæ conniventes are numerous and perfectly developed, and the calibre is greater. Peyer's patches are larger and more numerous in the ileum. The coils of the small intestines have no fixed position, but one may expect to find jejunum in the umbilical, left lumbar, and left iliac regions, while the ileum tends more to the right side, toward the hypogastric region and toward the pelvis.

Because of their wide extent and exposed position the small intestines are frequently injured. The degree of injury may vary from slight contusion to complete rupture, and is greater the nearer it approaches the stomach and the more distended the coils happen to be.

The extent to which the abdominal wall is injured does not indicate the severity of the visceral injury, for the most extensive laceration may follow a blow which scarcely leaves a mark upon the skin. The great dangers are hemorrhage and fecal extravasation, especially the latter. It occurs more rapidly from distended coils, and they are the ones most frequently injured. A longitudinal wound gapes more widely than a transverse, the edges being separated by the strong circular muscular fibres. A small penetrating wound may be plugged by everted mucous membrane. A wound in the mesenteric border is most difficult to repair. A gunshot wound in the lower left quarter of the abdomen will certainly inflict multiple intestinal injuries. As a rule, however, they will be found in a comparatively short loop of intestine, with a few scattered in distant coils.

Large Intestine.—Of this there are the following divisions: cæcum, ascending, transverse, and descending colon, sigmoid flexure, and rectum.

It is distinguished from the small intestines by its larger size, by its more fixed position, and by the appendices epiploicæ. Furthermore, the longitudinal muscular fibres which are spread in an even layer over the small intestines are gathered into three well-marked bundles on the surface of the colon. These are about one-half the length of the remaining colon layers, and so throw it into sacculations separated by transverse constrictions, which project into the lumen of the bowel as plicæ or valvulæ sigmoidæ. The length of the large intestine is five or six feet; its capacity is about one gallon. The cæcum—that part of the large intestine below the ileo-colic opening—is situated in the right iliac fossa, upon the ilio-psoas muscle. Anteriorly, it is in contact with the anterior abdominal wall above the outer half of Poupart's ligament, except when the omentum is interposed. Its exact position depends upon its peritoneal relations. As a rule, it is completely invested by peritoneum, though it has no meso-cæcum. In a small percentage of cases the upper part of the posterior surface is not covered by peritoneum, and so comes in contact with the areolar tissue of the posterior abdominal wall. It may be long and movable, its free extremity hanging into the pelvis or projecting across the mid-line to the opposite side of the body. Or it may be situated at any point between the iliac fossa and a position immediately beneath the liver, this being its location in the embryo of three months. The latter variation occurs in consequence of an arrest of its normal descent into the false pelvis.

When the posterior wall of the cæcum is not entirely covered by peritoneum, an infection readily travels from it to the areolar tissue about the right kidney. The *appendix vermiformis* originally arose from the apex of the cæcum, but, as the right half of the latter exceeds the left in development, the adult appendix arises from its inner and posterior surface a little below the ileo-colic opening. Its average length is between three and four inches, but it may vary from one to nine. Its cavity, lined by mucous membrane continuous with that of the cæcum, tends to undergo obliteration with advancing age. The lumen is narrowest at the orifice, which is guarded by a valve of mucous membrane. It is enveloped by peritoneum throughout, and is provided with a triangular mesentery derived from that of the small intestines. The mesentery is rarely complete, allowing the end to hang free. Within the mesentery is a branch of the ileo-colic artery, furnishing its blood supply. The exact position of the appendix is variable, but it will always be found by following one of the longitudinal bands of muscular fibres seen on the surface of the colon. Two main positions are observed. In one, the appendix is truly an intraperitoneal organ hanging free from the cæcum. It may be directed inward and upward, or downward: it may be curled on the brim of the pelvis or may hang into the pelvic cavity; or it may occupy one of the fossæ about the cæcum. In the second position the appendix is practically an extraperitoneal organ, lying between the posterior surface of the cæcum and the colon. The base of the appendix, as indicated by McBurney's point, lies two inches from the spine of the ilium on a line drawn from the spine to the umbilicus.

The ascending colon reaches from the cæcum to the under surface of the liver, passing through the right lumbar region into the hypochondrium. Here it turns to the left and becomes the transverse colon. As a rule, it has no mesentery, being held in position by the peritoneum which covers its anterior surface and sides. Behind, it is separated by loose areolar tissue from the quadratus lumborum and transversalis muscles and the lower and inner part of the right kidney. In front it is in contact with the anterior abdominal wall, omentum, and a few coils of the small intestines. The relation to the anterior surface of the kidney is most important. An abscess of the kidney or a perinephritic abscess may open into it without involving the peritoneum. A kidney enlarged from infection or a tumor carries the colon forward on its anterior surface. This may be determined by inflation of the colon. The transverse colon suspended by a meso-colon is deeply placed at its ends, but comes in close contact with the anterior abdominal wall in the remainder of its course. As a rule, it lies along the subcostal line, but may descend as far as the pelvis. Above, it is first close to the fundus of the gall bladder; adhesions between the two are common, and calculi may ulcerate into it from this viscus. The greater curvature of the stomach and the lower end of the spleen lie above in the remainder of its course.

The descending colon begins at the splenic flexure, at which point it is situated deeply in the left hypochondrium. From here it descends through the left lumbar region along the outer border of the kidney. Its peritoneal relations resemble those of the ascending colon. A relation worthy of notice is that to the kidney. The left kidney lies more internal to the descending colon than the right does to the ascending colon. Anteriorly, the descending colon is more constantly covered by omentum and small intestine than is the ascending.

Fecal matter may accumulate in the colon in any part to such an extent as to simulate a true tumor; consequently colonic flushing is always a wise procedure in the examination of an intra-abdominal growth.

The sigmoid colon, continuing the descending colon, extends from the iliac crest to the third sacral vertebra, at which point it becomes the rectum.

It is provided with a mesentery attached transversely in front of the psoas muscle. Its length and position are variable. It may form a perfect loop occupying the pelvis, or, when the bladder and rectum are distended, lying near the umbilicus. At times it rests in the left iliac fossa. It is this loop which surgeons open in a left inguinal colostomy. In the descending colon, the opening may be made through the posterior abdominal wall without exposing the peritoneal cavity, but as the position of the artificial anus is an awkward one for the patient the operation has been abandoned. The remaining portion of the large intestine is the rectum, situated within the true pelvis, with which it is usually described.

The *spleen* is situated obliquely behind the stomach in the epigastric and left hypochondriac regions. It lies beneath the eighth, ninth, tenth, and eleventh ribs; its long axis, measuring five or six inches, corresponds in direction with the tenth rib. It is separated from these ribs above by the lower border of the lung and pleura, and throughout by the peritoneum and diaphragm. A normal spleen cannot be palpated. The enlarged spleen appears beneath the costal arch at the level of the tenth and eleventh ribs. It may be distinguished by the notches, one or two, in its anterior border and by its respiratory movement. Unlike the movement of the liver, which is vertical, the movement of the spleen is oblique, that is, toward the umbilicus. The dulness of the spleen as outlined by percussion is an oval area extending from the ninth to the eleventh rib in the posterior axillary line. Four surfaces are described on the organ, each indicating a relation to a neighboring viscus. The phrenic surface is in contact with the diaphragm. The renal surface, directed downward and inward, is in contact

with the left kidney. The gastric surface faces forward and inward and is in contact with the posterior surface of the stomach; on this surface is the hilum. Finally, the lower blunt end is the basal surface resting upon the splenic flexure of the colon and the tail of the pancreas.

The peritoneal relations of the spleen are extensive. With the exception of the small region corresponding to the hilum it is covered by the visceral peritoneum of the greater sac. The blood-vessels and nerves reach the organ between the layers of the gastro-splenic omentum.

Wounds of the spleen are accompanied by severe hemorrhage. When it is extreme it may become necessary to remove the organ for this reason.

The *pancreas*, situated behind the stomach, in front of the first and second lumbar vertebræ, reaches from the concavity of the duodenum on the right to the spleen on the left. On the surface of the abdomen its position is from two and one-half to five inches above the umbilicus. To expose the pancreas the lesser peritoneal cavity must be opened. It is then seen lying behind the posterior layer of this cavity. It can be palpated only when pathologically enlarged, as by a carcinoma or cyst. The organ does not move with respiration.

The anterior surface of the pancreas is in contact with the posterior surface of the stomach, while the posterior surface lies in front of the aorta, the superior mesenteric artery, the splenic vein, and the left kidney with its vessels. The head is encircled by the duodenum. The pancreatic duct crosses the gland from left to right, and is buried in its substance close to the posterior surface. Its course is straight until it reaches the head, at which point it turns obliquely downward to enter the second portion of the duodenum, close to or in common with the bile duct. Retention cysts of the duct or of some of its smaller branches occur, and may attain a large size. In general appearance such a cyst resembles a solid or a cystic tumor of the kidney, the differential diagnosis being at times impossible.

Kidneys.—For the greater part the kidneys are situated deeply in the hypochondriac regions, their lower ends, however, extending into the adjacent lumbar and umbilical regions. In consequence of the position of the liver on the right side, the right kidney is somewhat lower than the left. As regards the vertebral column, the kidneys are opposite the twelfth dorsal, the first and second, and sometimes the third lumbar vertebræ. The upper end of the right kidney reaches a line drawn transversely outward from the tip of the spine of the eleventh dorsal vertebra. Its lower border reaches a similar line drawn from the lower edge of the spine of the second lumbar vertebra. This line is usually about an inch and a half above the iliac crest. Its upper end is nearer the spinal column than the lower. The pelvis of the organ is opposite the transverse process of the second lumbar vertebra.

Relations. The posterior surfaces are similar, but the anterior surfaces differ on the two sides. Posteriorly, the kidneys are not covered by peritoneum, being connected by areolar tissue with the diaphragm, the anterior layer of the lumbar aponeurosis covering the quadratus lumborum, and, more internally, the psoas magnus muscles. Above, the relation to the diaphragm is important, as this structure separates the kidney from the twelfth rib, and sometimes, on the left side, from the eleventh. An inspection of Plate I. will show that the pleura descends over the inner ends of these ribs, and so lies between the upper ends of the kidneys and the surface of the body. Notice especially that the pleura does not descend below the angle formed by the lower border of the twelfth rib and the outer edge of the quadratus lumborum muscle. However, the development of the twelfth rib is not constant, it being incompletely developed or entirely absent in many cases. The individual cases can be recognized only by counting the ribs. On the other hand, the lower limit of the pleura and its relation to the kidney are constant, and in a case of anomalous twelfth rib the pleura will lie unprotected by rib in this locality. The importance of this condition will be appreciated later.

Anteriorly, the right kidney has the following relations: At the extreme upper end is a small non-peritoneal surface in contact with the suprarenal capsule, below and external to which is a large peritoneal surface in contact with the liver. The area about the hilum is non-peritoneal and is in contact with the descending portion of the duodenum. Below this region and internal to the liver area are two regions: an outer non-peritoneal covered by the colon, and an inner peritoneal covered by coils of small intestines.

The anterior surface of the left kidney is crossed just above its centre by the pancreas, no peritoneum intervening. Above the pancreatic surface three organs are in relation with the kidney: the suprarenal capsule, the stomach, and the spleen—the first being the only organ not separated by peritoneum. Below the pancreas the surface is largely covered by peritoneum and small intestines, the exception being the outer border, which lies behind the colon. From the description of the situation and relations of the kidney a number of practical points are evident. As a general rule, it is safe to say that a palpable kidney is enlarged. Only in very favorable subjects, especially thin women, in whom the organ is frequently lower than normal, can we certainly feel the normal kidney, and then only the lower third, as the upper two-thirds lie behind the lower ribs. Bimanual palpation should be used, the hand placed in the loin being depended upon to lift the kidney against its fellow which presses upon the abdomen. In this connection note the position of the colon; it is nearly over the centre of the right kidney, but to the left of or outside the left kidney. The kidney has no respiratory movement. It is recognized by its characteristic shape, and, when possible, by the large artery which enters the hilum. The kidney may be reached through the loin or by way of the peritoneal cavity. In the former method various incisions are employed. The most important landmarks are the outer edge of the quadratus lumborum muscle and the twelfth rib. In all incisions it should be remembered that the pleural cavity is near, and it should be avoided. As indicated above, when the twelfth rib is of normal development, an incision may be carried closely into the angle between this muscle and the ribs. When the rib is short or absent, which is to be determined only by careful examination, then the location of the normal rib should be borne in mind, and the incision should be carried no farther than the normal angle. The attachment of the quadratus to the eleventh rib in these cases should not mislead one. The ureters occupy a position in the hilum posterior to the artery and vein. Their average length is seventeen inches. Beginning as a well-marked dilatation, called the pelvis of the kidney, the ureter passes downward on the psoas magnus as far as the brim of the true pelvis, which it enters by crossing either the common or the external iliac artery. It is accompanied by the spermatic vessels in the male, and by the ovarian in the female. This portion of the ureter may be reached through the post-peritoneal space. In searching for it the operator must raise the parietal layer of the peritoneum, to which structure it will be found adherent.

The *peritoneum* is a closed serous sac with the exception of the tubal openings in the female. It appears as though placed within the abdominal cavity in front of the viscera, the anterior or parietal layer of the sac lining the posterior surface of the antero-lateral wall, while the posterior or visceral layer is tucked about the viscera, enclosing them more or less completely, and attaching them to the abdominal walls. The exact relations of the membrane to the individual viscera have been noted in the descriptions of them, and are of importance in the spread of disease from viscera to peritoneum. Many injuries and diseases of the abdominal viscera are dangerous only as they involve the peritoneum. It is a well-known fact that an infection approaching the membrane from its outer surface is of much less danger than one approaching from the inner. The former is soon localized and results in the formation of an abscess; absorption of toxins is slight. When the inner surface is infected, the tendency of the disease is to spread rapidly, and the absorption of septic toxins is intense. These phenomena are explained by the microscopical structure of the peri-

toneum. Essentially it consists of two layers. The outer layer is composed of fibrous and elastic tissue. It supports the inner layer, which is of flat endothelial cells. Between the margins of the cells are numerous openings of lymphatic vessels, stomata. These are the active absorbents of the peritoneum. Some regions, as those of the diaphragm and small intestines, are especially rich in lymphatic vessels, while in others, as the omentum, the number is small. For this reason a peritonitis is more dangerous in certain localities.

When the antero-lateral wall is opened, the peritoneal cavity is opened also. In the living body, however, no cavity exists, parietal and visceral layers being held in contact by muscular action and atmospheric pressure. The great omentum is seen hanging from the greater curvature of the stomach, covering more or less completely the viscera in the lower half of the cavity. Normally it should do this quite completely, but it may be found collected in a roll about some organ or loop of intestine. This is especially the case when there has been a former peritonitis. The omentum serves to protect the intestines, and also as a storehouse for fat, but its most important function is that of limiting an infection. It readily contracts adhesions about organs, such as an inflamed appendix or a perforated intestinal coil, and so prevents infection of the general peritoneal cavity. In extensive pelvic suppuration, the omentum may completely exclude the pelvic from the general abdominal cavity. Behind the omentum are the small intestines, and, on either side of the posterior wall, the ascending and descending colons.

The mesentery of the transverse colon is raised with the great omentum. As it is attached transversely across the posterior abdominal wall, it divides the cavity into two compartments. The upper contains the liver, stomach, and spleen. It also includes the lesser peritoneal cavity. The lower compartment contains the small intestines and the colon. It is subdivided by the mesentery into an upper right portion and a lower left. The upper portion ends below in the right iliac fossa. Consequently a fluid effused in this region or on the upper surface of the mesentery will gravitate into the right iliac region. The left and lower portion passes into the pelvis, into which cavity fluid will descend when its origin is below and to the left of the mesentery.

The relations of the lesser cavity are described with those of the stomach. *Thomas A. Olney.*

ABDOMEN (SURGICAL).—The abdominal viscera, unlike those of the cranium and thorax, are contained within a cavity whose walls are composed chiefly of soft tissues and to a relatively slight extent of bony and cartilaginous structures. The viscera of the upper abdomen are protected in some degree by the lower ribs and their cartilages, and those of the lower abdomen by the pelvic bones, while posteriorly there is the lumbar spine.

The muscular wall of the abdomen, too, varies in thickness, and hence in its protecting properties, in different regions, being heavy and solid in the loins, and relatively thin at the sides and front.

These defences are more apparent than real, for while viscera may be shielded by them from the effects of violence acting in certain directions, practically all the abdominal contents are exposed to violence acting from in front.

The dangers of abdominal injuries depend also in no small measure upon the character of some of the viscera themselves.

The gastro-intestinal canal, although its mobility within the abdomen unquestionably enables it in many instances to escape the effects of violence, yet contains matter in a high degree infectious, which, finding its way into the peritoneum, regularly excites a dangerous and usually fatal peritonitis.

Distention of the hollow viscera also favors injury of them, for not only is there thus a larger mark for violence to act upon, but the increased tension of their walls facilitates the rupturing effect of violence. Others of the viscera, as the liver, spleen, kidney, and great vessels, are practically fixed and immovable, and therefore are subject to injury from a degree of violence sometimes comparatively slight.

The abdominal walls are lined by, and the viscera wholly or partially covered by, the peritoneum. This membrane, by rendering the movements of the abdominal organs upon one another and beneath the abdominal walls easy, no doubt often facilitates their escape from the results of violence which would otherwise inevitably produce injury of them, and thus it becomes a conservative agent.

On the other hand, peritonitis, however produced, is the most dangerous and oftenest fatal of the consequences of abdominal injuries.

Peritonitis developing as the consequence of injuries assumes one or other of three types. First, it results in the formation of adhesions between contiguous peritoneal surfaces, without pockets containing fluid of any kind; or, second, the adhesions form pockets shutting in collections of pus of greater or less size.

In both of these types the peritonitis is confined to some particular region of the abdomen and involves only a part of the peritoneum, the rest of it remaining uninflamed. Such types are distinctly conservative.

In contrast to them there is a third type in which the peritonitis, instead of being circumscribed, spreads quickly and soon involves the whole peritoneum. Such a type of peritonitis is usually fatal, while the first two are by no means necessarily so.

Peritonitis is invariably the result of infection by pus-producing bacteria either from without, through lesions of the abdominal walls, or from within, through lesions of the viscera, particularly of the gastro-intestinal canal.

Why, in different instances, different forms of peritonitis are produced, does not as yet seem evident. We have not the means for determining what is the rôle of the peritoneal cells and other defensive factors in combating infection. Several facts are apparent, however. Numerous experiments and observations have shown that the development of peritonitis is greatly promoted by the presence of blood in the peritoneal cavity; it is known also that infection by the contents of the intestine high up is milder than when escape of the contents of the colon occurs; and, finally, it is known that small fecal extravasations may be encapsulated, while large ones are usually followed by a general peritonitis.

Bile in moderate quantities may cause only an adhesive peritonitis; less frequently a general peritonitis follows. The same is true of perfectly normal urine; but decomposing urine, or urine containing inflammatory products or contaminated by unclean instruments—all of which are conditions implying the presence of bacteria—quickly excites a septic peritonitis.

It is convenient to classify injuries of the abdomen into two groups: (1) The subcutaneous, including contusions; (2) the open or wounds.

Subcutaneous injuries may be confined to the abdominal wall, or there may be lesions of the viscera also.

The open injuries may be confined to the abdominal wall without penetrating it, or they may simply penetrate the abdomen without injuring any of the viscera, or there may be a prolapse or a wound of the viscera.

Subcutaneous injuries of the abdominal wall result from the infliction of direct violence by blows, kicks, falls against obstructions, spent balls, passage across the abdomen of wheels, crushing by machinery, etc. In this group, too, are included those cases of overexertion in which muscles are ruptured. This accident is apt to occur in the recti, the diaphragm, or the erector spinæ, particularly in the presence of degenerative changes in these muscles.

Blood is extravasated between the retracted ends of the muscle torn by overaction or crushed by direct force; and after its absorption, repair occurs by cicatricial tissue, which may occasionally yield to intra-abdominal pressure and become the site of hernia. Ecchymosis also occurs

over wide areas beneath the skin or in the subserous connective tissue.

The WOUNDS of the abdominal wall which do not penetrate are not in themselves peculiar injuries. With proper treatment they heal readily; but care must be exercised in the accurate approximation of the cut muscles to prevent the subsequent development of hernia.

Another condition and one totally different presents itself the moment the peritoneum is penetrated; then the wound becomes a grave injury, with the possibility of peritoneal infection and septic peritonitis; but the dangers of such wounds depend upon their size, upon the implement by which they are inflicted, and upon the presence or absence of foreign bodies.

Small wounds inflicted by narrow, sharp blades are relatively innocuous and are usually recovered from; the visceral peritoneum, especially the omentum, becomes adherent to the abdominal wall in the region of the wound, the general cavity is shut off, and healing occurs without incident. In the case of larger wounds in which there is more or less gaping, or in those inflicted by dirty implements or complicated by the presence of foreign bodies, so great a surface of peritoneum is infected that no adequate adhesion occurs and a septic peritonitis follows. This may be prevented, however, in a certain proportion of cases at any rate, by proper wound treatment.

Through wounds of the abdominal wall, even if of small or moderate size, and almost certainly through those of any considerable dimensions, *prolapse* of one or other viscus, or of parts of viscera, is apt to occur. The omentum is most apt to escape; next the small intestine; and, when separated from their attachments, parts of the liver and the whole or portions of the spleen and kidney have been known to undergo a prolapse.

The viscus, especially if prolapsed through a small wound, soon becomes congested and œdematous, and adherent at the margins of the wound; it may then remain fixed there, or become wholly or partly necrotic.

Occasionally, as in the case of the omentum, the wound is plugged and permanently sealed; or a peritonitis spreads from the wound and destroys the patient's life.

The dangers which prolapse of viscera thus adds to those inherent in the penetrating wound of the abdomen, are the increased risk of peritonitis, unavoidable from the necessity of returning a prolapsed area of peritoneum almost certainly infected, and the likelihood of injury or of strangulation of the prolapsed viscera.

INJURIES OF SPECIAL VISCERA.

1. **The Liver and Its Ducts.**—While the liver is protected within certain limits by its position beneath the ribs and their cartilages, its relative fixity renders traumatic lesions fairly frequent.

Subcutaneous injuries are oftenest the result of crushing violence or of blows inflicted directly over the liver, and are not infrequently associated with fractures of the ribs, under which circumstances the bony fragments may be the agents by which the liver lesion is produced.

The lesion varies from slight subperitoneal laceration to fissures of some depth and extent, or even pulpification of the affected region or separation of masses of liver tissue.

The lesion occurs oftener in the right lobe than elsewhere.

Open injuries of the liver are usually the result of bullet or stab wounds, and the lesion itself varies from a small puncture to a large incision or hole.

In all these lesions, except those which are subperitoneal, bleeding is free and often profuse, and constitutes the main danger to life. Healing of the injured liver tissue occurs readily; but it may be interfered with by infection conveyed by the blood current or introduced from without.

The *prognosis* is modified in great measure by the presence or absence of associated injuries of other viscera. The mortality is reckoned by Edler* at 85.7 per cent. for contusions, 55 per cent. for gunshot wounds, 64.8 per cent. for stab wounds—average, 66.8 per cent.; for uncomplicated injuries, 54.6 per cent.

* Edler: Langenbeck's Arch., vol. xxxiv.

With or without injury of the liver itself the gall bladder or the ducts may be injured, and this may be followed by the escape of bile into the peritoneum in quantities more or less great.

Peritonitis regularly follows, but there are on record a considerable number of cases which are exceptions. In them, in subcutaneous injuries, the extravasated bile has been encapsulated, and the patient has been saved by repeated aspirations; or the bile has escaped externally through fistulæ formed in the tract of wounds, the flow gradually diminishing as these closed.

Treatment of injuries of the liver is directed chiefly to the control of the bleeding from them, and ought not to be delayed if the symptoms of loss of blood are increasing. It should be undertaken before exsanguination has proceeded far enough to make the additional shock of the necessary operative procedures a source of serious danger.

Hemorrhage from the liver may be stopped by gauze packing or by deep sutures; the cautery is useless.

The liver and its ducts are most accessible through incisions of the abdominal wall, made parallel with the margin of the costal cartilages; but it may be necessary to cut through the latter, or even to approach the liver through the pleural cavity and diaphragm.

Wounds of the gall bladder are to be sutured; in only the rarest cases is extirpation indicated. Incomplete divisions of any of the ducts should be closed as far as possible by suture, and in any case adequate provision for the escape of bile should be made by means of gauze packing.

In a case of complete division of the common duct, if approximation of the severed ends by suture seems impracticable, anastomosis between the gall bladder and intestine is clearly necessary.

2. **The Spleen.**—The deep-seated position of the spleen in the abdomen makes injuries of this organ relatively rare. Its injuries are the result of much the same sorts of violence as produce lesions of the liver. Of Edler's* 160 cases, 83 were subcutaneous, 42 were bullet wounds, and 35 were stabs.

It goes without saying that an enlarged spleen is much more liable to damage than one of normal size.

The intimate relation of the spleen to other abdominal (and thoracic) viscera makes associated injuries of these organs of frequent occurrence.

The great danger in injury of the spleen itself is from hemorrhage.

Suppuration and abscess of the spleen have been known to follow even subcutaneous injuries of the organ.

The *prognosis* is therefore grave. Of the subcutaneous injuries, Edler estimates that 86.7 per cent. are fatal; of the shot wounds, 83.3 per cent. The presence of associated injuries adds greatly to the dangers of the situation and increases the mortality.

The *treatment* of injuries of the spleen is chiefly directed to the control of hemorrhage. It should therefore be carried out at the earliest possible moment. The spleen is easily reached through an incision carried from the free border of the costal cartilages vertically downward through the outer margin of the rectus muscle. For relatively small wounds or ruptures of the spleen deep sutures may be used to stop the bleeding, but for more extensive injuries one should proceed without delay to extirpation.

3. **The Kidneys and Ureters.**—Contusions of the kidney occur not infrequently as the result of violence acting upon the loins in the form of kicks, blows, and falls. The lesion, in the mildest cases, consists in small subcapsular lacerations or in more extensive tears, particularly at the bases of the pyramids, while in the most severe cases the kidney is ruptured, split into two or more fragments, or reduced to pulp.

* Loc. cit.

Bleeding from the torn kidney tissue is apt to be profuse, and the extravasated blood infiltrates the retroperitoneal tissue or finds its way into the peritoneum if rents of this membrane are also present.

Wounds of the kidney are rare in civil practice, but they present in themselves no anatomical peculiarities that distinguish them from the subcutaneous injuries.

Repair of traumatic lesions of the kidney occurs with great readiness and completeness. Rarely, cysts persist at the site of injury or the kidney goes on to atrophy.

The danger to life in injury of the kidney lies first in the hemorrhage and then in suppuration. But the close relation of this organ to other viscera makes associated injuries of one or other of them of frequent occurrence, and thus the *prognosis* may be greatly modified.

Of 108 cases of contusion of the kidney collected by Grawitz,* 50, or 46.3 per cent., were fatal. Of these 50 cases, 18 were complicated by injury of more important viscera; in 17, suppuration occurred, with 7 deaths. Of the 32 uncomplicated cases, 14 died of the primary hemorrhage, 8 of secondary hemorrhage, 7 of suppuration, and 3 of urinary retention.

Of 50 cases of stab wound of the kidney, 15 were complicated by injuries of other viscera, 35 were uncomplicated. Of the 35 uncomplicated cases, 11 died—1 from primary bleeding, 1 from secondary hemorrhage, 6 from suppurative nephritis of the injured kidney, 2 from suppuration of the uninjured kidney, 1 not stated. Of the 15 complicated cases, 3 were complicated by injury of the spine, and all died; 1 by laceration of the peritoneum, fatal; 2 by injury of the liver, both died; 3 by injury of the intestine, 2 died; 6 by injury of the chest, 4 died; thus 12 died and 3 recovered.

Of 50 bullet wounds of the kidney collected by Edler,† 22 died. Of the 50, but 20 were uncomplicated by injuries of other viscera, and of these only 3 died.

Injuries of the ureter occur infrequently, most often perhaps as accidents in operations upon the pelvic viscera. Extravasated urine collects behind the peritoneum, exciting a cellulitis there, or it enters the peritoneal cavity and produces a fatal peritonitis.

The *treatment* of injuries of the kidney turns upon the control of bleeding, upon the provision for the escape of extravasated urine, and upon the avoidance of infection.

In contusions, therefore, if catheterism is practised at all, it must be done with every care to avoid introducing infection. For the less severe cases rest in bed is all that is required. For the more severe cases no delay is to be allowed in temporizing with urinary astringents, cold enemata, etc.; the kidney should be exposed and the bleeding controlled by suture, by gauze packing, or by partial or total nephrectomy. The external wound must be freely drained.

4. **The Bladder.**—The position of the bladder behind the symphysis renders injuries of this viscus fairly infrequent. Whether the wound be subcutaneous or open, the presence of the peritoneum over a portion of the bladder wall is of capital importance, and it is convenient therefore to divide injuries of the bladder into two groups—extra- and intraperitoneal.

Of the *intraperitoneal injuries* of the bladder, wounds may occur in any position, while the subcutaneous injuries or ruptures are usually transverse or oblique, of variable size, and occur oftenest low down in the posterior wall, and least often at the summit. They are usually due to blows or falls upon the hypogastrium, especially when the bladder is distended and the abdominal walls are lax.

There is free bleeding from the bladder lesion and escape of urine into the peritoneum; and sooner or later, generally within two or three days, a peritonitis is produced that, once established, has no tendency to remain circumscribed, but spreads and is regularly fatal. The promptness with which peritonitis develops depends in great measure upon the character of the extravasated urine and upon the presence or absence of infection introduced from without by instrumentation.

* Arch. f. klin. Chir., Heft 2, 1887. † Loc. cit.

The *extraperitoneal injuries* occur in the anterior wall of the bladder, and vary in size from mere punctures to considerable rents. They are due to much the same sort of accidents that cause intraperitoneal injuries, and are not infrequently the result of fracture of the pubic bones, in which accident fragments are displaced and perforate the bladder wall.

In these cases there is also free bleeding and an escape of urine into the cellular tissue of the prevesical space and into the subserous connective tissue; and, as a result of this, cellulitis develops in these tissues, and is practically always fatal.

As to the relative frequency of extra- and intraperitoneal ruptures of the bladder, the latter are much more numerous, being estimated by Fenwick* at 88 per cent., as against 12 per cent. for the former.

The *prognosis* of injuries of the bladder, even if uncomplicated by injuries of other viscera, is always most grave. Bartel† has collected 504 cases with a general mortality of 45 per cent. Of these, 373 were extraperitoneal, with a mortality of 20 per cent., and 131 intraperitoneal, with a mortality of 99.2 per cent.

Arranged according to the presence or absence of an external wound, 169 cases were subcutaneous injuries and 90 per cent. died, while 335 were open injuries and 22.7 per cent. died. Of the 169 subcutaneous injuries, 131 were intraperitoneal, with a mortality of 99.2 per cent.; 38 were extraperitoneal, with a mortality of 58 per cent. Of the 335 open injuries, 50 were stab wounds, with a mortality of 22 per cent.; 285 were bullet wounds, with a mortality of 24.5 per cent.

But these figures do not indicate the present mortality rate, which has undergone marked improvement with the advance of aseptic technique and the general adoption of earlier operative interference. Thus Schlange‡ has collected 32 cases, with 15 deaths and 17 recoveries. Of these, 22 were intraperitoneal with 10 recoveries, and 10 extraperitoneal with 7 recoveries.

The *treatment* of injuries of the bladder is designed to provide for the escape of urine and to close the bladder lesion itself, thus preventing infiltration of urine and the development of those inflammations which otherwise follow, and which are the immediate cause of death.

Suprapubic cystotomy, then, should be done at the earliest moment possible. In extraperitoneal injuries the lesion should be closed by suture, wholly or in part, Retzius' space should be thoroughly drained by gauze packing, and the bladder itself should be drained by a perineal tube.

In a case of intraperitoneal injury the abdomen should be entered just above the bladder, and thoroughly flushed, and the bladder itself should be closed by appropriate suture; a Mikulicz drain being passed into the depth of the pelvis and the bladder being drained by perineal tube.

If the ureter has been severed the divided ends may be brought together by the method of Hochenegg or of Kelly, or the kidney may be removed. Implantation of the ureter into the intestine is a hazardous expedient, as is also implantation into the bladder.

5. **The Gastro-Intestinal Tract.**—Injuries of the stomach occur less often than those of the intestine, and injuries of the large intestine are less frequent than those of the small. They may be single or multiple. Such injuries vary in extent, being either incomplete (involving only one or two of the layers of the tract) or complete (involving all of them).

The former group includes those cases in which the mucous membrane is lacerated by foreign bodies passing through the canal; those in which the intestinal wall is contused by violence acting from without, and in which the injury is accompanied by hemorrhage between the component layers of the intestine, and those in which there is laceration of the peritoneal or peritoneo-muscular layers.

Such injuries are relatively unimportant. Perforation

* Duplay et Reclus: "Trait. de Chir.," vol. vii., p. 686.
† Deutsche Chir., Lief 52, p. 67.
‡ Quoted by König, vol. ii., p. 140.

may be a consequence, but it probably occurs very infrequently. The complete lacerations are the important ones. They are of variable extent. In the stomach the lesion may be a minute perforation or a tear several inches in length; in the intestine also the injury may be a small puncture or a total transverse division of the bowel. There is more or less hemorrhage from the margins of the injured spot into the canal and into the peritoneum, and, most important, there is likely to be an escape of the contents of the intestine, the amount varying according to the dimensions of the opening.

The consequence may be either a peritonitis of small and limited extent, resulting substantially in nothing more than adhesions; or a circumscribed peritonitis, with abscess of greater or less size; or a generalized septic peritonitis.

In the smaller lesions, at least, extravasation of intestinal contents does not occur at once on the infliction of the injury, for one commonly finds, in operations done for bullet wounds of the intestine, that for some hours the opening is occupied and practically occluded by prolapsed mucous membrane. The mechanism of this occlusion was studied by Griffith,* who found that in transverse wounds of one-third of an inch in length, the mucous membrane is extruded by the contraction of the longitudinal fibres of the intestine, and that in small longitudinal wounds the contraction of the circular fibres causes the margins of the wound to roll in, expresses the mucous membrane, and produces the same occlusion. Such obstruction to the escape of intestinal contents is best seen in the small intestine, as it does not occur in the relatively thinner-walled parts of the colon.

Injuries of the gastro-intestinal tract result from contusions of the abdomen due to blows, falls, kicks, etc., which crush the intestine against the spine; and if this part of the canal happens to be distended when the injury is inflicted, an actual bursting of its walls may result. Penetrating bullet and stab wounds of the abdomen are a common cause of injuries of the intestines, and the latter may also result from the passage of a foreign body through the intestinal tract.

The *prognosis* is always grave and the chief danger is peritonitis. But the development of peritonitis varies with the extent of the lesion, with the ability of the patient to circumscribe peritoneal infection by forming adhesions, and with the promptness with which surgical intervention is undertaken.

According to Petry,† of 199 cases of rupture of the intestine, 4.8 per cent. recovered through the development of adhesions to neighboring structures; in 8.5 per cent. a circumscribed fecal abscess formed. The general mortality of ruptures of the intestine was 86 per cent.; of ruptures of the stomach, 80 per cent.

The seriousness of wounds of the gastro-intestinal canal will appear more clearly when I state that they are specially apt to be multiple and that other organs are apt to be wounded at the same time. Of 4,958 cases grouped by Coley,‡ the mortality was 81 per cent. Of 165 cases treated by operation the mortality was 67.2 per cent.; and of these, 81 concerned the small intestine (mortality, 67.5 per cent.); 24 the stomach (mortality, 75 per cent.); 36 the colon (mortality, 66.6 per cent.).

The *treatment* should be undertaken at the earliest moment. But here there is not the positive indication for instant operation that exists when the control of hemorrhage is the object in view. Nevertheless there should be no unnecessary delay in intervention, and the guide to the time of operation lies in the degree of shock present. The rule should be to operate the moment the general condition of the patient will admit of the procedures necessary, and before peritonitis has developed. In fact, after a peritonitis is under way and is spreading, no surgical measure is likely to be of avail in any but the most exceptional cases.

The lesions are to be sought systematically, and any existing tears should be closed by some one of the recognized forms of intestinal suture; or the intestine should be resected, or anastomoses should be made. Then the neighboring peritoneum should be cleaned; or the entire peritoneal cavity should be flushed until it is perfectly clean and then should be sponged dry. In most cases the judicious placing of gauze drains will be advantageous.

* Quoted by König, vol. ii., p. 143.
† Ibid., p. 144.
‡ Am. Jour. Med. Sc., March, 1891, p. 243.

6. **The Mesentery and Great Blood-Vessels.**—Injuries of these structures are exceedingly uncommon in subcutaneous injuries of the abdomen, but they occur with some frequency as the consequence of penetrating wounds. The great danger entailed is from hemorrhage, which is considerable in wounds of the mesentery even of small size, while in those inflicted at the root of this structure or involving one or other of the named branches of the aorta or vena cava, the bleeding is profuse and usually quickly fatal. *Treatment*, if available at all, is practically so only in those cases in which the wound involves the smaller vessels, which may be clamped and ligatured, or surrounded by suture, and so closed.

Symptoms.

To arrive at the proper conclusion in estimating the consequences of abdominal injuries it is essential to study the individual case from every point of view, beginning with the history of the injury itself, the degree of violence exercised, the attitude of the patient at the time of the occurrence, and the state of his abdominal viscera—empty or full, normal or diseased. Then, besides, one must note the sequence of symptoms, both the addition and the disappearance of local evidences, and the general condition of the individual considered as a whole.

Of the general symptoms, shock is apparent from the beginning in most cases of abdominal injury, although it varies in degree. It is most profound after severe contusions, and may be but slightly developed in a considerable number of cases of penetrating wounds of the abdomen, so that the absence of very marked shock should not be construed to mean absence of visceral lesions of serious or even fatal character; although profound shock must usually be interpreted to be indicative of grave injury.

The symptoms of hemorrhage are practically identical with those of shock, but they are gradually developed; and very often the similarity of the symptoms of the two conditions makes their distinction impossible, at least with any degree of certainty.

Peritonitis at its outset, which may occur within a few hours of the reception of an injury, sometimes closely resembles the symptoms of shock or hemorrhage, but when fully established it can hardly be mistaken for any other condition.

There are certain local symptoms which appear after injuries of any of several viscera, and there are others which are peculiar to lesions of special viscera alone.

Hemorrhage in any volume from the liver, spleen, or kidney,—extra- or intraperitoneal,—or from the mesentery, is accompanied by great pain, by distention of the abdomen, by great rigidity of its walls, by dulness in the flanks in some cases; but by no means all of these symptoms are present in every case in marked degree, and often one or more of them are absent altogether.

The presence of gas in the peritoneal cavity is indicated by loss of liver dulness and by a peculiar, non-resistant feeling of the abdominal wall on palpation and percussion. Here, again, exceptions are numerous in both the positive and the negative sense. Perforations of the intestine occur without loss of liver dulness, and liver dulness may be absent without perforation of the intestine.

Distention of the abdomen following injury is usually evidence of peritonitis.

Pain is often experienced at the site of injury, but is a better index of the location of injuries of the abdominal wall than of visceral injuries; it may be entirely absent or may be referred to another region, and is of little

value in determining any of the features of visceral lesions.

Tenderness, on the other hand, is of great value, and as a rule is felt only in the region injured, and is thus often an accurate guide to the location of the intra-abdominal trouble.

With injuries of the *liver* there is a history of wound or contusion in the region of the liver, followed by the local and general symptoms of hemorrhage.

With injuries of the *spleen* there is a history of wound or contusion in the region of the spleen, followed by the local and general symptoms of hemorrhage.

With injuries of the *stomach* there is a history of wound or contusion in the region of the stomach, or of the ingestion of a foreign body, followed by loss of liver dulness, by hæmatemesis, by peritonitis.

With injuries of the *intestine* there is a history of a wound or contusion of the abdomen followed by loss of liver dulness, by bloody stools, in some cases, and by peritonitis.

With injuries of the *kidney* there is a history of a wound or contusion in the region of the kidney, followed by evacuation of bloody urine, probably by tumefaction in the loin, and very often by the symptoms of suppurative nephritis and perirenal cellulitis.

With injuries of the *bladder* there is a history of a wound or contusion in the region of this organ. The symptoms and the conditions observed are the following: The bladder is very often, although not always, distended, and this condition is associated with apparent suppression of urine, with tenesmus, with evacuation of small amounts of blood through the catheter, with non-distensibility of the bladder by means of injections or with the return of smaller volumes than those injected, and, finally, with perivesical cellulitis or with peritonitis.

With injuries of the *mesentery* there is a history of a wound or contusion of the central region of the abdomen, followed by the local and general symptoms of hemorrhage or of intestinal obstruction and peritonitis.

With injury of any of the good sized vessels of the abdomen there are the symptoms of hemorrhage.

Diagnosis.

In most instances it is practically impossible to make a correct diagnosis of the viscera injured, and of the extent of the lesions present in consequence of injuries of the abdomen. It comparatively rarely happens that such injuries are confined to single viscera, and in the combination of symptoms that regularly ensue, some are overshadowed by others. This fact, together with the unreliability of many of the symptoms which should be pathognomonic of special injuries, renders the diagnosis always one of probability. Nevertheless, in a considerable number of cases the lesions probably present may be estimated with a fair degree of accuracy, and in a small number the diagnosis may be made with certainty; but it should be emphasized that this number is small, and that in these particular cases the injuries present are relatively slight. All the factors possible must be duly considered: the character of the violence; its degree and the particular region which it affects; the viscera present in this region and their condition at the time of injury; and both the immediate and the later symptoms produced. To all of these features proper value must be assigned before the final conclusion can safely be formulated.

Prognosis and Complications.

For the same reasons any statement in regard to the prognosis of abdominal injuries must be made with great caution. It may be said, however, that of those cases that recover after abdominal injuries, there are some in which the recovery is complete, and others in which it is incomplete (through the persistence of fistulæ or of peritoneal adhesions, or through the development of herniæ).

Of the complications of abdominal injuries, hemorrhage is perhaps the most important. It may accompany almost any of the visceral injuries.

Peritonitis is an almost equally grave complication. It is particularly apt to accompany injuries of the gastro-intestinal tract, the bladder, and the biliary ducts.

Later complications, as mentioned under prognosis, are: fistulæ communicating with the alimentary canal, the biliary passages, and the kidney; adhesions which possibly give rise to functional disturbances of the viscera and especially to intestinal obstruction; herniæ due to yielding of cicatrices of the abdominal wall; and, finally, the protrusion of one or other or several of the abdominal organs.

Treatment.

The treatment of patients suffering from the results of abdominal injuries is of a twofold character: it comprises the treatment of the general symptoms—those of shock, hemorrhage, or peritonitis—and the treatment of the local lesions present.

So far as the treatment of shock is concerned, the patient should be placed in bed and the foot of the bed should be elevated. He should be warmly covered, and artificial heat should be applied externally by hot bottles, etc. Heart action is to be stimulated by the application of heat or mustard paste over the precordium, by subcutaneous injections of strychnine, of morphine, of atropine, or of whiskey, and by enemata of hot water, fluid extract of coffee, and whiskey. In many cases, and in those particularly in which the symptoms are due to hemorrhage, the infusion of the patient with from forty to sixty ounces of normal salt solution is of the greatest possible service; but it should be borne in mind that the effect of the infusion will subside in about four hours, and that then the injection may have to be repeated.

All that it is necessary to say in this place in regard to the treatment of peritonitis has reference to its prevention, and this end is best served by the rigid observance of the rules which have been formulated for the aseptic or antiseptic treatment of wounds.

In the case of a wound of the abdominal wall, whether penetrating or not, the object of the local treatment is to secure union in the shortest time possible and in such a way that hernial protrusions are least likely to occur. For this purpose surgeons are fairly agreed that suturing must be done in layers, that is, that identical structures in each margin of the wound are to be united again; further, that such union is best accomplished by buried absorbable suture material, namely, catgut. But since catgut is absorbed within a few days, some other more enduring suture material must be used to preserve the apposition and beginning union, started between structures brought together by catgut. For this purpose, then, it is conventional to use deep sutures, embracing all the layers except the peritoneum, composed of silk, of silk-worm gut, or of silver wire. Finally, accurate union along the skin incision is obtained by a continuous suture of fine silk.

For *subcutaneous injuries* of the abdominal wall in which no rupture of muscle occurs, no special treatment is required beyond promoting the disappearance of extravasated blood by massage or aspiration.

When rupture of muscle occurs the overlying skin is to be incised and the injury treated as a wound by successive tiers of sutures.

When injury of one or of several of the abdominal viscera is certain or seems probable, no delay in instituting active treatment is permissible. It is far and away the better scheme to make explorative incisions through the abdominal wall, to render the diagnosis certain, than to subject the patient to the dangers of peritonitis or fatal exsanguination by waiting for a confirmation of the diagnosis of some doubtful or probable lesion by the development of positive symptoms. Many patients have without doubt been saved in consequence of this practice, and it is equally evident that many have been lost through hesitation in carrying out this scheme. There is little or no risk involved in the simple incision itself.

But no operative procedure may be undertaken in states of profound shock or in cases in which the injuries are so extensive or so complicated as to make their treatment practically impossible; nor should interference be resorted to in the presence of well-marked peritonitis. On the other hand, in the presence of a beginning peritonitis there still remains some possibility of success.

If decided shock is present, energetic measures for its relief are called for, and only when the patient has begun to rally, that is, when the pulse becomes slower and stronger and the temperature begins to approach normal, may an operation be contemplated. The exception to this rule is met with in those cases in which the symptoms of apparent shock are due to hemorrhage. In such cases no substantial improvement is likely to result from stimulation, and the patient's best if not only hope lies in immediate intervention, during which active stimulation should be carried on.

For the treatment of any visceral lesion that is a consequence of a non-penetrating injury of the abdomen it is necessary to incise the abdominal wall, the position, direction, and extent of the incision being determined by the viscus to be reached.

To expose the liver and biliary ducts, an oblique incision parallel with the free border of the ribs, with its centre about opposite the tenth cartilage, is conventional, while a similar incision on the left side exposes the stomach. But for either purpose a vertical incision through the outer part of the rectus downward, for variable distances from the free border of the ribs, serves equally well, and has the advantage that on the right side the kidney may be explored and attacked through it, while on the left side the spleen may also, if necessary, be reached.

To expose the kidney by the transperitoneal route, the incision just described is the best; but for general purposes the König incision of the loin is much to be preferred in every way, since in itself it is extraperitoneal, but at the same time it allows the peritoneal cavity to be entered very readily by extending the incision forward but a short distance.

For the purpose of reaching the bladder an incision carried upward from the symphysis between the rectus muscles for the necessary distance, with the patient in the Trendelenburg position, exposes this organ perfectly; and, in order still further to enlarge the working space, the insertions of the recti into the symphysis may be divided for a short distance. Then, by the aid of retractors placed so as to draw the margins of the wound apart, one may obtain a perfect view of the bladder, and ample room may be gained for any suturing operation.

To gain access to the intestine and mesentery a median incision through the linea alba, of variable length and carried around the left side of the umbilicus, will answer the purpose best. In this way the small intestine and mesentery, the rectum, and the sigmoid flexure may readily be reached, and by use of vigorous retraction the rest of the colon may be exposed, as well as the first and second parts of the duodenum.

In making incisions through the abdominal wall, no time should be lost in using a director. The incision should be rapidly carried through the skin, the superficial and deep layers of fascia, and the muscles—clamps being applied to all bleeding points—until the transversalis fascia is reached. This is to be nicked with the knife and then divided along the length of the wound by scissors, thus exposing the peritoneum. The latter in turn is then to be pinched up by two pairs of forceps, a nick is to be made between them, and the membrane is then to be divided by scissors on a finger thrust beneath it through the small primary opening. It is optional whether bleeding points are to be tied before entering the cavity or whether clamps are to be left *in situ*.

In the operative treatment of *penetrating wounds* of the abdominal wall, it is best to enlarge the wound of entrance with the same precautions that are usually observed in formally opening the abdomen. Having done so, one should inspect the subjacent viscera, and then upon ascertaining the extent and character of the lesions to be treated, should, if necessary, make additional incisions through the abdominal wall in one or other of the positions, and in the manner just described, or the wound should be still further enlarged. The treatment of the injuries of different viscera has been referred to under the description of their lesions.

Here it is proper to indicate the method of caring for prolapse of viscera, and for blood and foreign material which may be present in the peritoneal cavity.

Almost any of the viscera, whether injured or not, may prolapse through wounds of the abdominal wall, and then be injured, or infected, or become strangulated; and the procedure to be adopted depends upon which of these events has occurred.

In general terms, for purposes of treatment, it is always to be assumed that prolapsed viscera are infected; and whether a given viscus is to be returned or not will be decided by the possibility of rendering it practically aseptic or not, of repairing injuries present in it, or of restoring its circulation.

Prolapsed omentum should in any case be tied off and removed.

Prolapsed intestine, if strangulated, may be sutured *in situ*, or may be opened in such a manner as to form a fecal fistula which is to be closed subsequently, or it may be resected at once. If it has become infected it is to be subjected to very thorough mechanical cleansing with 0.5-per-cent. salt solution, and then returned after any injuries possibly present in it have been repaired.

Prolapse of the spleen calls for its removal if strangulated or irreparably injured, or for its return if it can be thoroughly cleaned and repaired.

Prolapsed portions of the liver are to be removed.

Prolapse of the kidney should be managed by removal if it is necrotic or very greatly injured; by mechanical cleansing, repair, and replacement of the organ if it be possible. However, in any case ample drainage must be provided by gauze leading from the site of the returned viscus to the surface.

Blood is to be completely removed from the abdominal cavity. This is done by scooping out clots with the hand and sponge, and by copious douchings with hot salt solution. Provision for subsequent drainage need not necessarily be supplied.

The entrance of foreign bodies from without or from the intestine, or the entrance of intestinal contents into the peritoneal cavity, is a fruitful source of peritonitis, and measures should be taken to prevent its occurrence. But once they have invaded the cavity and infected it, no time is to be lost in removing them and in neutralizing their consequences.

Intestinal contents are to be removed by scooping and sponging, and then not only the visibly soiled areas of peritoneum must be cleansed by the liberal use of salt solution, but the same procedure must be carried out with regard to the whole peritoneum, especially if considerable quantities of foreign material have escaped; and, if necessary, evisceration must be resorted to. Drainage must of course be provided in every case.

Drainage of areas of the peritoneum is best accomplished by the use of gauze—ordinary absorbent gauze sterilized, or gauze impregnated with iodoform. Gauze has the advantage over tubes of various kinds in several respects. Besides the perfect manner in which it enables all exudate to be carried to the surface, it decidedly promotes the formation of adhesions about itself, and consequently about the region drained, which is often infected, and further oozing is best checked by the pressure exerted by the gauze packing.

Gauze introduced for drainage purposes is used in ribbons, one or more of which are so placed as to lead from the area drained; or larger pieces of gauze may be packed into the region to be drained and brought out of the abdominal wound; or the Mikulicz dressing may be used. This consists of a piece of iodoform gauze about fifteen inches square, doubled back from its centre like an umbrella, and containing strips of gauze so arranged

that one after another can be withdrawn without disturbing the enveloping skirt, which is last to be removed.

The period for withdrawing drains varies somewhat with the purpose for which they have been introduced; gauze placed to stop oozing should be removed in from twenty-four to forty-eight hours, while that used to drain infected or inflamed areas is allowed to remain in place some days longer.

The treatment of the sequelæ of injuries, as fistulæ, ventral herniæ, etc., does not naturally come under the present title. *Percival R. Bolton.*

ABDOMINAL TUMORS, DIFFERENTIAL DIAGNOSIS OF.—The word tumor is used here not in the restricted sense of a neoplasm but in the etymological sense of a swelling. It is at once evident from this that a large number of pathological processes affecting all the organs contained in the abdomen and the tissues making up the abdominal walls must be considered. This was deemed necessary because we start with the assumption that in a certain given case a tumor has been found in the abdomen and it is necessary to discover what and where it is. All details of etiology, pathology, and symptomatology have been omitted except in so far as they have a direct bearing upon the differential diagnosis. For such details reference must be made to more special articles. Furthermore, the diagnosis of conditions which ultimately lead to the formation of demonstrable tumors has been omitted, and the discussion of such conditions will be limited to their course after the formation of a tumor. For example, when speaking of cancer of the stomach it will be assumed that a tumor has been discovered.

When confronted with an abdominal tumor, it must be remembered that the diagnosis should go beyond the mere recognition of the existence of a tumor in the abdomen. We must determine first the organ or tissue in which the tumor is located, and second the nature of the tumor. If the tumor is believed to be a malignant neoplasm, we must decide, if possible, whether the tumor arose in the organ in which it is discovered or is merely a tumor secondary to a primary tumor in some organ yet to be determined. If the tumor found is believed to be primary, secondary deposits in other organs must be sought. In other cases we must hunt for the cause of the tumor. If, for example, a certain tumor is thought to be a gall bladder distended with fluid, effort should be made to ascertain the character of the fluid and the cause and site of the obstruction which prevents the escape of the fluid from the gall bladder. With so broad a subject it is evident that only the more important methods, facts, and pathological conditions can be included.

After a brief discussion of the methods of examination employed, we will consider what might be called tumors of the abdomen as a whole, such as ascites, diffuse peritonitis, lipomatosis. Then the various organs will be grouped according to their relations to the colon, and each group considered in turn. The organs situated to the cephalic side of the transverse colon, the liver and gall bladder, the stomach, pancreas, and spleen, will be described first; then will follow the organs behind the colon, the kidney, adrenal bodies, and perirenal tissue; next will come the organs within the arch of the colon, the small intestines, mesentery and omentum, peritoneum, lymph glands, aorta, uterus, ovaries, bladder, spinal column, and lastly the colon, appendix, and walls of the abdomen. With each organ we shall as far as is possible take up first the circulatory disturbances, then the inflammatory processes, cysts, neoplasms, and malpositions. It is not necessary to state that this order cannot be followed absolutely, but it can be approximately, and will be found greatly to facilitate a grasp of this subject, probably the most difficult matter handled by the diagnostician.

Methods of Examination employed include the I. physical, II. chemical, and III. microscopical: the first having in general an especial bearing upon the localization of the tumor, while the second and third are of more value in determining the nature of the tumor.

I. *Physical Methods*—(A) Inspection. The patient should be placed on a firm narrow bed or table in such a way that the source of the light lies in a line with the median line of the body, either directly above or at the head or foot of the patient. The purpose of this is to avoid any uneven distribution of the shadows. The kind of light employed is usually a matter of indifference, but in cases in which there is reason to suspect the possibility of a jaundice the patient must be examined by daylight, for the well-known reason that no artificial light shows even the deepest shades of jaundice.

Take note first of the size of the abdomen, especially of any disproportion between the size of the abdomen and that of the other portions of the body. Next note the shape of the abdomen. Is the abdomen symmetrical? Are there any portions more prominent than the corresponding ones of the other side, or is the upper half out of proportion to the lower half? If any part appears large, does it appear sharply outlined or does it merge gradually into the surrounding parts? Does the surface of the enlargement appear smooth or nodular, and are the outlines rounded or irregular? Does the mass move; and if so, does it move with the respiration, the pulse, or independently of either? Almost any tumor of the abdomen may show respiratory or pulsatile movements (the exceptions will be stated later), but only a few show independent movements. These are tumors from the stomach, intestines, and uterus. Visible vermicular movements of the stomach and intestines are commonly seen in patients with thin abdominal walls and are not in themselves pathological. It is only when they are unusually intense and continuous and in combination with distinctly pathological symptoms that they need attention. The word vermicular quite accurately describes the motion, for it looks exactly as if some large worm were moving under the skin. The site and direction of the movement should be noted. In general the peristaltic movements of the stomach are limited to the upper and median portion of the abdomen and pass from left to right. Peristaltic movements of the stomach from right to left are pathological. The movements of the small intestines are central and irregular in direction. Those of the large intestine correspond to the relatively fixed position of the colon and vary in direction with the portion of the colon affected. The peristaltic movements above the site of any stricture in the gastro-intestinal tract, either acute or chronic, are more active than normal, and therefore persistently exaggerated movements point to some obstruction, but do not in themselves prove such obstruction.

The independent movements of the uterus are of two sorts: fœtal and uterine. The presence of the fœtal movements is at times a most important point in the differentiation of abdominal tumors. The movements are altogether irregular in time and intensity, and may be simulated by the peristalsis of the small intestines. The expulsive contractions of the uterus are not often visible, but may be so.

Inspection of the abdomen includes attention also to any subcutaneous collateral circulation, either arterial or venous. Such circulation often gives the clew to the site of the obstruction, which necessitates a collateral circulation and may give some idea of the degree of the obstruction. Note also any localized œdema or inflammatory process.

Often much valuable information may be gained by changing the amount of gas in the stomach and intestines. Not only do we gain information as to the exact location and size of these organs, but we learn much of their relation to the tumor found. Various methods have been employed for this purpose, but the following require only such apparatus as should be in the armamentarium of every physician. The stomach may be inflated by means of a Seidlitz powder mixed after drinking instead of before, or one can use saleratus in solution followed by a little vinegar. This method is not entirely without danger, because the pressure resulting from the gas evolved cannot be accurately estimated. Accidents, however, are rare. Another method consists of the passage

of the stomach tube and inflation of the viscus by means of a pump. This has the advantage of enabling one to use as much or as little gas as desired, and permits the immediate removal of the gas if necessary.

The colon is inflated by passing the rectal tube well up into the descending colon and forcing in air by means of a pump, the ordinary bicycle pump being perfectly adapted to the purpose. A rather large, cone-shaped rectal tip is better than the rectal tube, for it prevents the escape of the air, but is not so easily supplied as the tube. As the air passes upward and distends the colon we are able to learn the exact course of the colon and its relations to the tumor.

Harris, of Chicago, has recently drawn especial attention to the value of the relation of the colon to abdominal tumors in the differential diagnosis of such tumors. He substitutes for the old and superficial division of the abdomen into nine areas—the right and left hypochondriac, lumbar, and inguinal regions, the epigastric, umbilical, and hypogastric regions—an anatomical division into four areas. The borders of these areas are not fixed by external points, but are located by the inner or mesial layer of the longitudinal colon and the inferior or caudal layer of the transverse colon. The resulting areas are a central area, surrounded by mesocolon; a right and left posterolateral area, lying external to and behind the mesocolon; and a superior area, lying above the transverse mesocolon. While the boundaries of these areas are not fixed, their position is easily ascertained by determining the position of the colon by air distention.

In the central area, surrounded by the distended colon, are found tumors of the omentum and mesentery, retroperitoneal tumors, localized peritoneal exudates, tumors of the small intestines, tumors of displaced and movable kidneys, and all tumors of the female generative organs rising into the abdomen.

In the superior region we find tumors of the liver, gall bladder, stomach, lesser omentum, pancreas, retroperitoneal lymph glands, and aneurisms of the cœliac axis.

Tumors of the spleen pass forward close to the anterior wall, in front of the splenic flexure of the colon and the neighboring parts of the transverse and descending colon.

Tumors of the kidneys, suprarenal bodies, and the connective tissue bordering on these organs, tumors from remains of the Wolffian bodies, carry the colon inward and forward. But tumors from floating kidneys may appear in the central area, *i.e.*, surrounded by the colon.

(B) Palpation. This method of examination is of much more general application than inspection, for many tumors easily palpable are not visible. Palpation should always be preceded by thorough and certain evacuation of the bowels, otherwise fecal masses may lead to errors. The patient should be examined first in the dorsal position, but in some cases a lateral, a knee-chest, or an erect position will yield results not otherwise obtainable. The patient should relax the abdominal muscles as completely as possible. This is often easier when the thighs are flexed on the abdomen and the mouth held open. In difficult cases better relaxation is obtained if the patient is placed in a bath of warm water and examined in the bath. In still more difficult cases general anæsthesia must be employed. Palpation should be made gently but firmly, and any pressure used should be applied gradually; counter-pressure from behind is often a help. Sometimes, and this is especially true when there is considerable fluid in the abdominal cavity, one obtains the best results by dipping the stiffly held fingers suddenly downward, depressing the abdominal walls to varying depths. Bodies can often be felt and outlined in this way that cannot be felt at all by the ordinary method of palpation.

Attention should be given to the following points: the location, size, shape, motility, and tenderness of the tumor. Note also any change in position or ease of palpation caused by distention of stomach and colon.

In all cases in which it is impossible absolutely to exclude a neoplastic origin for the tumor palpated, the rectum and vagina should be examined.

(C) Percussion. This method is far less valuable here than in examination of the chest, but should never be omitted, and in certain cases exceeds the other methods of examination in value. Its main uses are the determination of the position of the diaphragm, the shape of the upper border of the liver, the presence or absence of free fluid in the abdominal cavity, and the position and approximate size and shape of the stomach and colon after they have been distended by gas or fluid. Percussion is the main means of determining the relation of the colon and stomach to the tumor found, and what was said under the heading of Inspection in this regard could be repeated here; might perhaps have been more properly placed here, for percussion is used much more often than inspection for this purpose.

Tumors of the abdominal organs cause abnormal areas of dulness only when superficially located or of large size, and the resulting area of dulness is always smaller than the tumor.

Percussion is valuable in demonstrating the absence of areas of dulness normally present. Disappearance or reduction of the hepatic and splenic dulness is often of the highest diagnostic value. Disappearance of the posterior renal dulness is less so.

In isolated cases auscultatory percussion gives valuable results.

(D) Auscultation. Almost no results are obtained by this method. Peritoneal friction, either localized or diffuse, is sometimes heard. Arterial and venous tones and murmurs are common and usually of but little significance.

(E) Exploratory Puncture is often of the very greatest value, especially in determining the nature of the tumor. The details will be given later.

(F) Exploratory Laparotomy. In certain cases a complete diagnosis—*i.e.*, one which localizes the tumor and determines its nature—is impossible even after the most careful examination. In such cases an exploratory laparotomy is often justifiable, providing it can be made by a competent surgeon under favorable circumstances. Unless the patient presents some obvious contraindication to the operation, it can be done with almost no danger and often gives information which leads to definite curative treatment.

II. and III. The *chemical* and *microscopical methods* of examination can be more profitably discussed in the special paragraphs referring to the different organs.

Before taking up the various diseases of the abdominal organs leading to tumor formation, it should be expressly and emphatically stated that any examination of an abdominal tumor which omits a complete and careful examination of the entire body is criminally incomplete. Abdominal tumors are often merely symptoms of diseases of organs remote from the abdomen, and such primary disease can be discovered only by a complete examination of the body.

Enlargements of the Abdomen as a Whole.—This may occur as the result of accumulations of gas or fluid in the peritoneal cavity, from large amounts of gas in the intestines, from deposits of fat in the abdominal walls, omentum, and mesentery, and in rare instances from very large tumors.

Ascites.—This is the only common cause for extreme enlargements of the abdomen. The abdomen is enlarged in all diameters, but when the cavity is not completely filled, as is ordinarily true, the horizontal diameter when the patient is in the dorsal decubitus will be found considerably greater than the perpendicular diameter. The flanks are bulging while the umbilical region is flattened. The skin is often tense and shining, and under it can be seen the overdistended veins. Such veins are present in all well-marked cases of ascites irrespective of its cause, but are usually better marked in cases due to atrophic cirrhosis of the liver than in others. The umbilicus is flattened out or even bulging. Sometimes when the patient changes position, one sees the fluid changing position also, and one is reminded of the appearance of an incompletely filled sack when it is shaken.

On palpation the fluid waves can be felt when the hand is placed flat on one side of the abdomen and the other side is percussed gently. If one lays the hand lightly over the region of the abdomen which percussion shows to be tympanitic and at the same time percusses the flank, the fluid will flap up and strike the hand, *i.e.*, the fluctuation is felt over the tympanitic area.

Percussion shows dulness over the dependent portions of the abdomen, but usually about the umbilicus one finds an area of tympany. The borders of this area are not regular, but wavy. If one outlines this area very carefully he will find that though the borders are wavy, they are at all points in the same horizontal plane. When the position of the patient is changed, the level of the fluid changes very promptly to correspond to the altered position. When the amount of the fluid is very great, the entire abdomen will be dull on percussion, even at the highest level.

Auscultation yields no results, except in cases to be stated later.

Such free fluids in the abdomen are usually transudates, but they may be exudates, and the first question is to determine which. Usually this can be done with a great degree of certainty even without actual examination of the fluid. If the patient has a perfectly manifest disease of the heart, kidney, or liver, the fluid is very probably a transudate. If there is fluid in the subcutaneous tissues and the other serous sacs also, this probability becomes a certainty.

If doubt remains, enough fluid must be withdrawn to ascertain its character. In these cases it is best to remove at first only sufficient for examination, for when the fluid is chylous it is best not to withdraw it except upon the most urgent indications. A transudate is a clear, straw-colored fluid, of low specific gravity, less than 1.015, containing a small amount of albumin up to two per cent. and showing almost no cellular elements. An exudate may be equally clear, but is usually cloudy from cells and fibrin. The specific gravity is above 1.015, usually considerably above. The amount of albumin is higher, over four per cent. The cellular elements vary greatly in number and in character, but are always more abundant than in the transudate.

The rather rare cases of adipose and chylous ascites show a turbid, milky fluid, very different from the ordinary ascitic fluid. The adipose ascites is usually of high specific gravity, for it is merely an altered exudate, contains a good deal of fat which is in both large and fine droplets, and is free from sugar. The chylous ascites contains fat, but only in fine droplets; sugar is present in most, but not in all cases; the specific gravity is low.

When it is settled that the enlargement of the abdomen is due to free fluid, and the nature of the fluid, whether exudate or transudate, has been discovered, it yet remains to determine the cause of the trouble. Large peritoneal transudates may come from a disease of heart, kidney, or liver. If due to heart or kidney, the ascites is usually a part of an anasarca; if due to the liver, the ascites exists alone or preceded the œdema elsewhere by days or weeks. A well-marked collateral circulation on the abdomen and an enlarged spleen speak for a primary hepatic process, but it may be necessary to withdraw the fluid before the spleen can be palpated.

Large exudates in the abdomen are almost always due either to tuberculosis or to carcinoma. The physical signs often differ somewhat from those of the transudate, because as a rule the fluid is not perfectly free and for this reason does not change its level so promptly as does the transudate, and oftentimes certain portions of the intestines become adherent to the abdominal wall, so that tympany is found even over the most dependent part of the abdomen. The clinical differentiation of tuberculous from carcinomatous peritonitis is often very difficult. If the patient is too young for carcinoma or there is a manifest carcinoma or tuberculosis of some organ, then it is easy; but there are many times when it is difficult. The positive reaction to the Koch tuberculin speaks for tuberculosis, a leucocytosis speaks for cancer, but these two sometimes contradict each other. The development of cachexia speaks for cancer. In doubtful cases the patient should be laparotomized for purposes of diagnosis and treatment, if the latter is found possible.

There have been numerous instances of confusion of ovarian cysts with free fluid in the abdomen, both transudates and exudates. There is little excuse for this error unless the ovarian cyst is so large as to fill completely the abdomen. Here attention to the history, which in these cases runs back for years, together with the absence of any demonstrable cause for free fluid, will usually enable one to make the diagnosis. As a further aid one may make an exploratory puncture. The fluid of ovarian cysts presents characteristics to be described in a later paragraph.

Sometimes great dilatation of the stomach has been mistaken for ascites, the air and fluid in the stomach giving the same physical signs as free fluid in the abdominal cavity. The history of this condition differs from that of the ascites. In cases of any doubt, the stomach tube, by withdrawing any fluid in the stomach, will enable one to make the diagnosis with certainty.

Collections of gas in the free peritoneal cavity often cause a very considerable increase in the size of the abdomen, but percussion and the tympany thus developed clearly prove the nature of the enlargement. Whether the gas is in the intestines or in the peritoneal cavity is often difficult to decide when both are possible, as after trauma or in the course of some ulcerative process in the gastro-intestinal tract. Here the progressive decrease in the size of a liver dulness, known from former examinations to be present, speaks for gas in the peritoneal cavity. It is usually associated with shock and symptoms of peritonitis.

Enlargement of the abdomen from fat is common, and is readily recognized, as a rule. We sometimes see lipomata of the mesentery or omentum, which present themselves as tumors of the abdomen and are really such, but it is not to these which we refer. Careful examination of this very common condition will protect one from error.

Tumors of the Liver.

The pathological processes causing enlargement of the liver may be well placed in two groups, according as the enlargement is diffuse or circumscribed. It must, however, be stated that this division, like most other divisions in medicine, is not at all sharply marked, for most of the pathological processes may occur in either group. For example, amyloid infiltration usually causes a diffuse enlargement of the liver, but may cause sharply circumscribed masses; while, on the other hand, carcinoma usually causes localized masses, but may cause diffuse enlargements.

Diffuse enlargements of the liver, no matter what the cause, bring about no change in the general shape; the liver is, so to speak, merely magnified. The borders lose their normal sharpness and become rounded and thickened. The notch in the anterior border for the gall bladder is retained. The consistency of the liver is often altered, usually becoming firmer, but sometimes it feels softer. The surface may be perfectly smooth or slightly granular, depending upon the pathological process in play. A granular surface may be simulated by the presence in the subcutaneous tissues of partially atrophied adipose tissue, but under such circumstances the granules can be felt all over the abdomen, and they feel more superficial than granules in the liver.

Diffuse enlargements of the liver generally take place downward rather than upward. Percussion shows that the upper border of the liver occupies its normal position; presents its normal shape, that of a straight line perpendicular to the surface on which the patient is lying; and shows only a slightly decreased respiratory mobility.

Passive Congestion of the Liver.—This is the commonest example of a diffusely enlarged liver, and inasmuch as the subjective symptoms from which the patient suffers

may be, and often are, entirely limited to the hepatic region, the tumor of the liver is often mistaken for some primary condition, while in reality it is not primary but always a mere symptom of some disease causing obstruction to the venous circulation at a point above the juncture of the hepatic veins with the inferior vena cava.

The subjective symptoms are pain, fulness, tension, and weight in the right hypochondriac region, either constant or intermittent. These symptoms may, and often do, overshadow all other symptoms of the primary disease. Examination shows a uniformly enlarged liver, reaching usually only a few centimetres below the costal arch, but sometimes extending to or beyond the umbilicus. The surface is smooth, the borders are regular but rounded. Usually, but by no means always, the liver is tender. Percussion shows a regular upper border with normal respiratory motility.

The patients often show a moderate degree of jaundice, usually both conjunctival and cutaneous. The jaundice is practically never intense unless there is some complication. This jaundice is apt to still further strengthen the idea that the patient has a primary disease of the liver. Examination of the abdomen shows an absence of ascites and no enlargement of the spleen. Exceptionally both these are found, but in these cases the symptoms of cardiac insufficiency are so marked that only the most careless can mistake them.

Examination of the chest will in most instances show that the primary disease is oftenest a disease of the heart, endoperi- or myocardial. The cardiac insufficiency may, however, be secondary to some disease of the lungs or pleura, oftenest an emphysema or an obliterative pleuritis.

All patients who present an enlarged liver, especially when the liver is painful or tender, should be examined for some disease of the heart, lungs, or pleura as a possible cause for a passive congestion; and if such disease is found, the liver should be regarded as a liver of passive congestion; and this diagnosis should be given up only on the strongest evidence pointing to some other disease causing diffuse enlargement of the liver.

Passive congestion of the liver is liable to rapid fluctuations, so that marked changes in the size of the liver can occur in the course of a few days or even hours. Such fluctuations do not, however, always occur, and the enlargement may remain stationary over weeks and months.

Active Congestion of the Liver.—This occurs in a variety of conditions, but is usually of so slight a degree as to pass unrecognized, or if found, is so minimal or so manifestly of secondary importance as to attract little attention. It occurs in a variety of infectious diseases, the most important examples being scarlet fever, smallpox, the various forms of sepsis, typhoid fever, and malaria. Malaria, especially the estivo-autumnal malaria, may cause a marked and persistent enlargement of the liver which may be difficult to diagnose. Such cases may present an icteric discoloration of the skin, with marked enlargement of the spleen, thus closely resembling the hypertrophic cirrhosis of the liver, a disease which often gives rise to an intermittent fever resembling the fever of malaria. The differentiation between the two is made by an examination of the blood for the Plasmodium malariæ. Malarial enlargements of the liver may persist after the plasmodium has disappeared from the blood, in which case attention must be paid to a history of prolonged and irregular malarial fever.

A variety of poisonings, especially those by phosphorus and arsenic, may cause acute congestive enlargement of the liver

Biliary obstruction due to obstruction of the common duct, when continued for any length of time, often causes a marked enlargement of the liver. The enlargement is perfectly uniform and is accompanied by pain and tenderness. The jaundice is intense and progressive. The stools are usually acholic. The constitutional and other symptoms present are due in part to the jaundice and in part to the cause of the obstruction. The only disease of the liver liable to be confused with the swelling due to biliary retention is the hypertrophic cirrhosis, for both present a uniform enlargement of the liver plus jaundice, and both may be accompanied by fever. There are these points of difference: The hypertrophic cirrhosis is accompanied by a splenic tumor; the jaundice is usually not complete, *i.e.*, the stools still contain bile; and pain and tenderness are absent as a rule. With biliary retention there is no splenic tumor, the stools contain no bile, and there are also present the symptoms of the primary condition causing the obstruction, such as gall stones, acute catarrhal jaundice, a tumor at the porta, etc.; ascites is more common than with hypertrophic cirrhosis.

Hypertrophic Cirrhosis of the Liver.—This gives rise to a universal enlargement of the liver, exactly resembling the enlargements just considered, so far as the shape of the swelling is concerned. The enlargement is in general greater, but the size is of no value in the differentiation. There is usually no pain or tenderness, merely an uncomfortable sense of weight and fulness. The patient usually gives a history of one or more attacks of jaundice, brought on by slight indiscretions in diet or occurring spontaneously. Each succeeding attack is longer, and the intervals between the attacks become progressively shorter. Usually these cases appear for treatment because of a jaundice, the intensity of which varies greatly, but in general is not so intense in this disease as in others to be mentioned later. The stools are not acholic as a rule, although they are often lighter colored than normal, and in some instances are completely acholic.

Examination shows an enlarged liver and practically always an enlarged spleen. This enlargement of the spleen is very constant and is often extreme, so that the spleen reaches a hand-breadth or more below the costal arch. The spleen, like the liver, is not tender and, like it, feels hard and dense. Inasmuch as this form of cirrhosis respects the portal veins, there are no signs of passive congestion of the abdominal viscera. There are no evidences of a collateral circulation. Ascites does not appear until the terminal stage.

Hypertrophic cirrhosis is sometimes accompanied by irregular fever or by fever regularly intermittent, and under such circumstances may require differentiation from malaria and from infections of the bile tracts. The history of previous attacks of malaria or of residence in malarious regions is important. The blood should be examined for the Plasmodium malariæ. In these cases the demonstration of the malarial organism often requires repeated examination of the blood, and, in case of repeated failure, an exploring needle should be put in the liver or spleen and the blood thus obtained examined. The plasmodia are often found in the blood of these organs when they cannot be found in the circulating blood.

Infections of the bile tracts, even when acute, may resemble the hypertrophic cirrhosis by causing marked enlargement of the liver, with jaundice and splenic tumor. The liver is, however, often tender, and the enlargement may be irregular; the spleen often feels soft, the fever is usually more marked, the chills are more prominent. An examination of the blood will in many cases show a leucocytosis and sometimes bacteria. The difficulty of differentiation is still further increased by the fact that many patients with hypertrophic cirrhosis suffer during the later stages from infections of the biliary tracts.

Syphilis of the liver occurs in various forms, but we are concerned only with those forms which lead to enlargement of the liver. Either the acquired or the hereditary variety of syphilis may cause an increase in the size of the liver, though they do so by different processes.

Tertiary syphilis, the stage in which the liver is oftenest enlarged, leads to the development of gummata in varying number and arrangements. These gummata, undergoing absorption, lead to gross irregularities in the configuration of the liver. Much liver tissue is destroyed, and the remaining portions undergoing hypertrophy to counterbalance the loss, still further increase the deformity. The symptoms resulting from gummata in the liver are very variable, as may be readily imagined when one recalls that there may be any number of gummata in

the liver, and that they may be located about the porta or be scattered more or less indifferently through the liver.

The marked peculiarity of this form of syphilitic liver is its moderate increase in size plus the very gross and irregular lobulations. The constitutional symptoms may be marked or slight, but there are usually some gastro-intestinal symptoms. Ascites is rare and usually does not appear until late. When present, it may be moderate or excessive, and it is liable to marked spontaneous variation in amount. It reappears rapidly if withdrawn by paracentesis.

There is not usually any subcutaneous, abdominal, collateral circulation.

Jaundice is exceptional. Splenic tumor is common.

The diagnosis is based mainly upon the irregular liver, residua or a history of syphilis, which was either not treated at all or treated but imperfectly.

Hereditary syphilis may affect the liver in a variety of ways, but in contrast to the effects of acquired syphilis it is much more often a diffuse instead of a circumscribed process. The changes in the liver may be apparent at birth, or appear during early childhood, or be delayed until adolescence. The earlier they appear the more easily the nature of the process is recognized, for in the young other processes in the liver are rare as compared with syphilis. The symptoms are often indefinite. The children are poorly nourished weaklings, suffering from gastro-intestinal disturbances, often rachitic. The spleen is usually enlarged; ascites is not uncommon, but icterus is the exception. The manifestations of syphilis on the skin and mucous membranes are often minimal. The diagnosis is based mainly upon the recognition of the opportunity for the existence of hereditary syphilis; in other words, the diagnosis is based upon an examination of the parents.

Fatty Liver.—There are a considerable number of pathological conditions in which the liver is enlarged from the presence of fat, either deposited or formed *in situ*. Such a liver is enlarged, usually, only to a moderate degree; retains its shape; is not tender or painful. It does not cause jaundice or ascites, or lead to the development of a collateral circulation.

The recognition of the natuıe of the process causing the enlargement of the liver rests on a recognition of the cause for fatty degeneration or infiltration. The commoner causes are over-eating and the excessive use of alcohol, especially when combined with insufficient exercise. Enlargement of the liver is frequently found in alcoholics without the pathological process in play being manifest. The liver will be found enlarged, the patient suffering from moderate gastro-intestinal symptoms, and examination fails to show any change in the other organs. In such cases it is impossible to decide whether the patient has a fatty liver, a congested liver from the gastro-intestinal irritation, or a beginning hypertrophic or atrophic cirrhosis. Any of these conditions will disappear if the alcoholic abuses are stopped. If this is not done, a few years will settle the question. If the spleen is found enlarged the condition is probably one of cirrhosis.

Diseases which interfere with oxidation, either by reduction of the hæmoglobin or by reduction of the breathing surface of the lungs, often cause a fatty liver. Thus fatty livers are seen in many cases of primary anæmia—in chlorosis, for example—and in many cases of pulmonary tuberculosis. It occurs also in cases of other exhausting diseases, such as prolonged suppuration, chronic dysentery, pernicious anæmia. A variety of toxic bodies, notably phosphorus, arsenic, and antimony, cause fatty liver.

Amyloid Liver.—The diagnosis of this condition rests upon two factors: the recognition of a sufficient cause for the amyloid, and the recognition of amyloid changes in other organs. The liver is enlarged, often enormously so, and the enlargement is usually generalized, but exceptionally the deposits of amyloid are localized, forming large and sharply circumscribed tumors. The surface of the liver is smooth and regular. It feels firm and dense, and is not tender or painful. Jaundice does not occur, and ascites when present develops late and is the ascites of cachexia, preceded by œdema of the extremities. The amyloid process does not often reach a high degree in one organ before it begins in other organs also. For this reason we do not find the amyloid liver without similar changes in spleen, kidney, and intestines. The spleen is enlarged; the urine is abundant and contains considerable albumin with granular and waxy cysts; and there are often gastro-intestinal disturbances, especially a diarrhœa due to the amyloid changes in the intestines.

The cause of the amyloid may lie in any chronic infectious disease, oftenest chronic suppuration of the bones and joints and pulmonary tuberculosis. It occurs also in syphilis, chronic malaria, chronic dysentery, and sometimes in the later stages of carcinoma and other malignant tumors.

Amyloid changes must most often be distinguished from the fatty liver seen in many of these conditions because of the common etiology, and from hypertrophic cirrhosis because of coincident changes in spleen and gastro-intestinal tract. The fatty liver in general feels softer than the amyloid liver, and, what is more important, is not accompanied by enlargement of the spleen, albuminuria, and diarrhœa.

The hypertrophic cirrhosis, while presenting an enlarged spleen and gastro-intestinal symptoms, is associated with recurring attacks of jaundice, something never seen as the result of amyloid, and the causal conditions for amyloid are absent.

Résumé of the Uniform Enlargements of the Liver.

Passive Congestion.—Liver enlarged, painful, tender, liable to sudden variations in size; spleen not enlarged; jaundice moderate or absent and altered in tint by the usually accompanying cyanosis; ascites, if present, preceded by œdema of the feet; examination of thorax will show cause for passive congestion.

Biliary Retention.—Liver enlarged, painful, tender; spleen not enlarged; jaundice intense and the stools acholic; may or may not be fever; ascites present or absent; symptoms of the condition causing obstruction, such as gall stone, catarrhal inflammation, or tumor, present.

Hypertrophic or Biliary Cirrhosis.—Liver enlarged, not tender or painful; spleen enlarged; jaundice actually present or found one or more times in history; ascites only in terminal stage.

Syphilis of the Liver.—Acquired: enlargement general, but grossly irregular; may be pain and tenderness; jaundice and ascites usually absent; spleen not enlarged; history and residua of syphilis. Hereditary: enlargement uniform, without pain or tenderness; jaundice and ascites usually absent; spleen enlarged; other marks of hereditary syphilis and existence of syphilis in the parents.

Fatty Liver.—Liver large, smooth, soft; spleen not enlarged; no jaundice or ascites; presence of cause, as general lipomatosis, alcoholism, anæmia, etc.

Amyloid Liver.—Liver enlarged, smooth, firm, not tender or painful; spleen enlarged; jaundice and ascites absent; diarrhœa and albuminuria present; the presence of a cause for amyloid, as prolonged suppuration, tuberculosis, syphilis, etc.

This practically completes the list of processes causing diffuse enlargements of the liver, except the enlargements seen in leukæmia and pseudo-leukæmia. These will be considered in the paragraphs upon tumors of the spleen.

Localized Enlargements of the Liver.

Of the processes which cause circumscribed enlargements of the liver, there are three which far exceed all others in importance. These are the abscess, the cancer, and the hydatid cyst. Any one of these, however, may cause diffuse enlargements, just as most of the processes usually causing diffuse enlargements may at times cause circumscribed tumors.

Abscess of the Liver.—The pyogenic organisms, streptococci, staphylococci, pneumococci, bacillus coli, amœba, etc., may reach the liver through any of its five sets of vessels, but oftenest through the portal vein, the biliary ducts, or the hepatic artery. Infections through the hepatic artery are usually part of a general septicopyæmia which so overshadows the infection of the liver that the latter has only a pathological interest.

Most often the organism enters through the portal vein. The infection atrium in the intestines is furnished oftenest by dysenteric ulcers, and for this reason abscesses of the liver are commonest in Southern countries, where dysentery is commonest. In the temperate zones the primary disease most common is appendicitis, but ulcerative processes anywhere along the intestinal tract, especially along the large intestine, may cause infection through the portal vein.

Bacteria may enter the liver from the bile ducts either directly from ulcerations of the ducts, excited by gall stones or other causes, by extension up along the bile ducts, or by entering the vessels of the bile ducts and thence reaching the portal vein.

The symptoms are both constitutional and local. The patients are often emaciated, cachectic, with yellow-colored skin (not often, however, due to jaundice), and marked anæmia, usually accompanied by leucocytosis. Fever occurs in most cases, at least at some time during the course of the disease, and may be continuous, intermittent, remittent, or hectic in type. Chills may or may not be present.

Locally, there is pain, usually preceded by a sense of weight and fulness. The exact location of the pain varies with the site of the abscess—oftenest in the right hypochondriac region. It varies greatly in character as it does in intensity, but in general is more severe if the abscess is located near the surface of the liver. Radiation of the pain to the right shoulder is quite common.

Examination of the liver shows it to be enlarged, and the general tendency is for the liver to enlarge upward instead of downward. The border between the liver and lung is no longer a straight line, but one curving upward to a varying degree. The respiratory excursion of this line is retained, unless there is an old pleuritis with adhesions complicating the hepatic condition. If the abscess is located in the left lobe of the liver there may be marked dislocation of the heart.

If the abscess points toward the skin there may be localized bulging of the abdominal wall with œdema of the skin.

Jaundice is rare with liver abscesses, as is also the ascites. When the latter is found, it may be due to pressure on the portal vein, or to the general cachexia, and be merely a part of a general anasarca.

The spleen is not enlarged with the chronic abscess unless it has become amyloid.

Exploratory puncture will often settle any doubts as to the nature of the process, but one must remember that there are some dangers in making the puncture. The greatest danger is that of infecting the peritoneal or pleural cavity on withdrawing the needle from the abscess cavity.

The diagnosis will often be cleared by the rupture of the abscess into some organ, as the lungs, stomach, or intestine, and the escape of the pus outward.

The diagnosis of the solitary abscess of the liver is based mainly upon the symptoms of sepsis, with local pain and tenderness, with physical signs of a localized enlargement of the liver, with history of dysentery, appendicitis, hemorrhoids, or gall-stones. The diagnosis is certain when pus is obtained by aspirations.

When the abscess is very large and the enlargement of the liver mainly or solely upward, the condition may be mistaken for pleurisy; but attention to the history of the case, and especially to the respiratory motility of the upper border of the dulness, will settle the question.

Cancer of the Liver.—While other neoplasms occur in the liver, the cancer is so much more common than all others combined that it alone will be considered. Cancer may occur primarily in the liver, but this is decidedly exceptional while secondary cancer of the liver is comparatively frequent. The cancer is oftenest primary in some organ in connection with the portal system—the stomach, rectum, pancreas, uterus—but the primary tumor may be anywhere. The secondary tumor or tumors may far exceed the primary in size.

Examination shows the liver enlarged, often to an extreme degree, and in suitable cases the liver can be seen to enlarge from day to day. The enlargement may be nearly uniform, but in most cases it is plain that the enlargement is irregular. Sometimes the prominences in the liver can be seen and their respiratory motility followed by the eye. More often they can be felt as round, usually firm, hard prominences, sometimes distinctly umbilicated on the surface. They may be tender. Sometimes the peritoneal covering is inflamed and the resulting friction can be palpated. Percussion shows the irregular enlargement of the liver, and here also especial attention should be paid to the upper border of both the superficial and deep hepatic dulness.

In addition to these symptoms due to the presence of the tumor we may find symptoms due to the pressure which the tumors may exert upon neighboring organs. Thus the common bile duct may be obstructed and icterus result. The icterus tends to become rapidly and steadily worse.

The spleen is found enlarged in about ten per cent. of the cases.

Ascites is not uncommon and may be due to compression of the portal vein, to an accompanying carcinomatous peritonitis, or to the general exhaustion. The ascites is often sufficiently marked to entirely mask the tumors in the liver, which can be discovered only after the removal of the fluid, which may be either serous or hemorrhagic. The patients with cancer of the liver show a progressing secondary anæmia with leucocytosis, together with a rapidly developing cachexia, accompanied usually by considerable pain in the right side. There are no febrile symptoms unless caused by some complication.

Having found a tumor of the liver, a circumscribed enlargement which, from the general condition and age of the patient, and from the absence of symptoms of abscess or echinococcus cyst, seems to be a cancer, one should search for the site of the primary tumor, paying especial attention to symptoms pointing to disease of the stomach, pancreas, rectum, uterus, or to any of the other common sites for carcinoma, as the breast, etc. Even in the absence of such symptoms it is probable that the cancer of the liver is secondary.

Echinococcus Cysts.—Many cases cause no symptoms whatsoever and are therefore unrecognized until the cysts reach considerable size, and even then may be purely accidental findings. When small they cause no functional disturbances unless located at the porta or superficially, where they may excite a painful perihepatitis. Usually the first thing to attract attention is a palpable tumor or symptoms resulting from pressure upon some organ.

Hydatid cysts enlarging downward are much more easily palpated than those enlarging upward. The cyst is round, firm, elastic, sometimes fluctuating, although in many cases, when the tension of the walls is great, there is none. The size of the tumor varies over a wide range, but may be so large as to extend even into the pelvis or far upward into the thorax.

Percussion shows the tumor to be dull, and in a certain number of cases gives the so-called hydatid thrill, which is probably a fluctuation phenomenon in which the individual waves are very short because of the tension of the fluid, the elasticity of the walls, and the homogeneity of the cyst contents. The phenomenon is not found in all cases of hydatid cyst and is not absolutely peculiar to it, for it is found with other forms of cyst when the peculiar physical conditions are present.

Percussion is especially valuable when the cyst enlarges upward into the thorax. It enables us to determine the upper border of the cyst. The upper hepatic border is no longer straight, but presents a bulging up-

ward corresponding to the cyst. The respiratory motility of the borders is unimpaired unless there is or has been a complicating pleuritis, something which is not uncommon.

Functional disturbances resulting from pressure upon the various abdominal and thoracic organs vary with the organs affected and with the degree of the pressure. These symptoms are often far more marked than those from the liver itself.

Compression of the portal vein or the inferior vena cava may cause ascites and other circulatory disturbances, which may entirely obscure the presence of the cyst. Icterus may result from compression of the common duct.

Constitutional disturbances from these cysts are practically wanting except as the results of pressure upon neighboring structures or of secondary infection of the cyst with pyogenic organisms and the conversion of the cyst into an abscess.

From this brief outline it is evident that the clinical picture of the echinococcus cyst varies greatly, and the diagnosis is often difficult. The main elements in the diagnosis are the demonstration of a circumscribed enlargement of the liver, unaccompanied usually by marked constitutional disturbances, and yielding to exploratory puncture a fluid which may vary in character, but which contains elements which are absolutely peculiar, namely, the echinococcus hooklets and scolices. These are so peculiar that they will be immediately recognized by any one who has ever seen the pictures found in all text-books upon diagnosis.

When small the cyst must be differentiated from other processes which cause localized enlargements, particularly the abscess and cancer. Both these are accompanied by marked constitutional disturbances, which in the case of a cyst are conspicuously absent.

Pain is usually present with abscess or with cancer, while it is usually absent with cyst. The history of a residence in certain parts of the world, notably Iceland, or of constant association with dogs, is a point in favor of the cyst.

Exploratory puncture will remove all doubt, but here, as with the abscess, this is not entirely free from danger.

A very sharply localized cyst might, by enlarging downward, simulate a distended gall bladder, but could not assume the peculiar pear shape of the gall bladder, nor would it present the motility of the gall bladder. The history of the patient would moreover be different.

When the cyst is larger and grows downward it needs differentiation from cysts of other organs, such as the pancreas, ovaries, or kidneys. Usually the differentiation is easy from the history and from the shape and location of the tumor. In the exceptional cases, close attention should be given to the relation of the colon to the tumor. This is pushed down and usually back by cysts of the liver, forward by cysts of the kidney, upward by cysts of the pancreas and ovaries.

When the cyst enlarges upward, it may require differentiation from a pleuritis exudativa. Ordinarily the history of an acute onset with pain, fever, and the peculiar shape of the dulness will speak for a pleuritis. In cases of pleurisy with insidious onset, when the exudate is large and unaccompanied by manifest constitutional symptoms, especial attention should be paid to pressure effects on the heart. With pleurisy the heart is dislocated outward, with cysts the displacement is more often upward and outward. In cases which are doubtful the exploratory puncture will decide.

The true nature of the cyst is often learned from its rupture into some neighboring organ, such as the stomach, colon, lungs, when the hooklets, scolices, and daughter cysts may appear in vomitus, fæces, or sputum.

The multilocular echinococcus is even less common than the cystic form, except in certain parts of Europe where it is not infrequent. The onset is insidious and usually without symptoms until the disease has made great progress; then weight and pain in the epigastrium and right hypochondrium appear, with gastro-intestinal disturbances. Icterus and ascites are common and often appear early. The liver is often greatly enlarged, and with irregularly distributed tumor masses so that its surface is grossly lobulated. The border is often irregular and very hard. The liver usually shows its normal respiratory motility. The spleen is often enlarged.

The condition must be differentiated from multiple carcinomata of the liver, which differ in their more rapid course, marked cachexia, blood changes, and age of the patient and show also the symptoms caused by the primary cancer. In most parts of the world, cancer of the liver is of almost daily occurrence, while the multilocular echinococcus cyst is extremely rare. In cases which cannot be differentiated in this way, make an exploratory puncture.

Hypertrophic cirrhosis and syphilis of the liver may be simulated. Both these conditions are relatively common. With the cirrhosis, the jaundice is usually not so intense and it varies from time to time, the splenic tumor is more common, ascites is rare, and the enlargement of the liver is more uniform. With syphilis of the liver the individual enlargements in the liver are not so large or hard and the liver is more irregular; jaundice, ascites and splenic tumor are less common. Here also exploratory puncture may be necessary.

There are a number of other pathological processes which cause localized enlargements of the liver, such as sarcoma, fibroma, adenoma, and cysts, but they are so exceptional that their consideration may be omitted from an article of this sort.

Corset Liver. Tight lacing, either by means of a corset or by a string about the waist, often causes a deformity of the liver which in extreme cases may cause a condition simulating a tumor. This may be due to an elongation of the liver because of the pressure to which it has been subjected, and its true nature is then easily recognized. Sometimes, and this is more often when the constriction of the waist has been made with a string instead of a corset, the right lobe, rarely the left, is elongated and the part directly below the pressure is atrophied so that a larger or smaller mass of liver tissue is separated from the liver and connected to it by a band of fibrous tissue. The shape, size, and motility of such a mass vary in the different cases. It must often be differentiated from movable right kidney. It differs in shape from the kidney, lies nearer the front wall of the abdomen, and lies in front of the colon instead of behind it. Attention to the shape of the thorax and to the history of lacing is also of assistance.

Movable Liver. This forms a tumor on the right side, one which may extend downward to the pelvis or far over to the left of the median line. At the same time the liver tilts so that the convex surface lies forward. The form of the liver is unchanged. This, together with the absence of liver dulness in the normal site and the fact that in most cases the liver can be returned to the normal site when the patient is in the dorsal decubitus, makes the diagnosis easy.

Tumors of the Gall Bladder.

With occasional exceptions these are merely distentions of the gall bladder with bile, mucus, or pus, either alone or in combination with stones. The degree of distention varies from just sufficient to admit of palpation of the gall bladder, as a small rounded projection below the edge of the liver in the parasternal line, to a sac capable of holding a litre or more. The larger the bladder the more it assumes a long, pear-shaped form—extending downward from the liver just beneath the abdominal wall. With increasing size, the motility increases until the bladder can be moved freely from side to side and backward, but it always tends to return to its position just beneath the abdominal wall. It also shows distinct respiratory motility. The tumor feels smooth, elastic, and sometimes fluctuation can be made out. Rarely the friction of stones moving over one another can be felt.

Usually palpation alone shows the presence of the tumor, but in favorable cases, when the abdominal walls

are thin, its presence, shape, form, and respiratory motility are visible. Percussion also may show its presence.

An enlarged gall bladder practically always lies in front of the colon and intestines, and to the right and partially in front of the stomach. Inflation of the colon and stomach is sometimes necessary in making the diagnosis.

Usually the anatomical location of the tumor, its shape, motility, and manifest relation to the liver facilitate the recognition of the tumor as one from the gall bladder, but when the distention is extreme it may be confused with a hydronephrosis or a cystic ovary. Attention to any history of disturbances of the urinary or genital tract and the demonstration of the relation of the tumor to the colon—which lies behind a distended gall bladder, in front of a hydronephrosis, and above a cystic ovary—will remove all doubt. In addition to these points the gall bladder is attached above to the liver and is free below, while an ovarian cyst is attached below and remains free above. The hydronephrosis arises manifestly from behind.

The diagnosis of the cause of the dilatation of the gall bladder and the finding of the site of the obstruction may be a simple or a difficult matter. Repeated attacks of biliary colic would suggest a stone; acute gastro-intestinal symptoms with jaundice would suggest an acute catarrh of the ductus choledochus; and progressive cachexia with gastro-intestinal symptoms would suggest a carcinoma of some of the organs near the porta.

The diagnosis of the nature of the fluid in the cystic bladder (pus, bile, or mucus) is, like the diagnosis of the cause, easy or hard. If accompanied by jaundice, it is probably bile, and the obstruction is in the common duct. If there is no jaundice, the fluid is probably mucus, but may be bile or pus, and the site of the obstruction is at the neck of the bladder or in the cystic duct. An empyema of the gall bladder is accompanied by the ordinary constitutional disturbances of suppuration, but the presence of such symptoms, when the gall bladder is distended, does not in itself prove that the fluid is pus.

Exploratory puncture of the gall bladder is ordinarily too dangerous to be justifiable.

Cancer of the Gall Bladder.—This is on the whole a rare disease, and the diagnosis is based upon the demonstration of a hard, nodular, slowly growing tumor in the region of the gall bladder, accompanied by cachexia and anæmia. The diagnosis is strengthened by a history of biliary colic, and by the exclusion of carcinoma of any of the organs frequently causing metastases in the liver.

Tumors of the Stomach.

The methods employed in the examination of the abdominal tumors so far considered have been almost entirely physical, aided sometimes by microscopical examination of the blood. With cases of tumors of possible gastric origin, chemical methods of examination become prominent; but unfortunately, in spite of the immense amount of study and work which has been put upon them, their results are often uncertain and contradictory, so that they no longer receive the respect formerly paid them.

The pathological processes which can cause a tumor of the stomach are very numerous, but most of them are so uncommon that they need no mention in an article of this sort. The processes which demand our attention are the cancer, the ulcer with scar formation, and dilatation of the stomach. We would remind the reader that it is assumed throughout this article that a tumor is palpable. Considerations relating to the diagnosis of these conditions previous to the appearance of a palpable tumor must be sought in more special articles.

When a tumor is found in the neighborhood of the stomach, two questions must be answered: Does the tumor arise from the stomach, and what is its nature?

Cancer of the Stomach.—The subjective symptoms resulting from cancer of the stomach vary greatly—in one case being prominent, in another almost wanting. There is, moreover, no necessary proportional relation between the size of the tumor and the intensity of the symptoms. The symptoms also vary with the site of the carcinoma; in fact, this has a very marked influence upon the intensity of the symptoms. Cancer at the cardia or pylorus need not be large to cause very marked symptoms, while one on the curvatures of the stomach may be very large and yet cause almost no subjective symptoms.

In general there are symptoms pointing distinctly to the stomach, but these symptoms are not peculiar, for they consist of a loss of appetite, especially a loss of appetite for meats, distress and fulness after eating, eructations both gaseous and acid, pain either constant or after eating, nausea, and vomiting. These are symptoms which may occur with any disease of the stomach, but when they begin late in life, especially if the patient has always been free from gastric disturbances, they should always suggest the possibility of a cancer of the stomach. When in addition to these the patient vomits the well-known coffee-ground vomit, the possibility becomes almost a probability. Along with these gastric symptoms there develops a progressive, secondary anæmia, accompanied by leucocytosis, and in time the cancer cachexia, with its peculiar earthy-colored skin, emaciation, and œdema, appears, and gives the patient so peculiar a look that the diagnosis can often be made on sight.

Examination of the functions of the stomach often gives most valuable assistance in the diagnosis. More attention has been paid to the secretory function of the stomach than to its other functions, although a consideration of all three is important. Briefly summarized, the result of the study of the gastric secretion is as follows: In almost all cases of cancer of the stomach the hydrochloric acid eventually disappears, but is often present until late, and may be present until death. It may be present even in excessive amounts. There are a large number of other diseases of the stomach in which also no hydrochloric acid is found; one might even say that there is no disease which may not cause absence of hydrochloric acid. One must, therefore, give up the idea formerly current that an absence of hydrochloric acid is pathognomonic of cancer of the stomach, and be content with the fact that it is more frequently absent with cancer than with any other one disease of the stomach. The inverse statement of this proposition is of much more practical value. The continuous presence of hydrochloric acid speaks strongly against a carcinoma, but does not absolutely exclude it, as it is found until death in about ten per cent. of the cases.

Lactic acid is found in many cases of cancer, but is absent in many, and present in other conditions in which the food stagnates and ferments, so that the presence of lactic acid does not have the diagnostic value at first assigned to it.

The absorption time is prolonged in most cases of cancer. The motive power is lessened.

Far more significant than all of the symptoms so far enumerated is the demonstration of a tumor in the region of the stomach. Such a tumor mass can be found in about eighty per cent. of all cases, but unfortunately its demonstration often occurs late, long after the time when surgical interference is advisable. When a tumor connected with the stomach is found in a person who is over thirty and who has beginning cachexia, the diagnosis of cancer becomes certain. Without the demonstration of a tumor the diagnosis of a cancer of the stomach is merely one of greater or less probability. The more advanced the age, the more marked the cachexia, the more conspicuously gastric symptoms are present and symptoms of other diseases are absent, the greater this probability becomes.

In some cases the tumor manifests itself, upon inspection of the abdomen, as an irregular mass in the epigastrium or lower in the abdomen, often moving freely up and down with the respiratory movements. The distention of the stomach sometimes has an effect upon the ease with which the tumor is seen. It may make the tumor visible or may completely obscure it. Inspection often gives im-

portant information as to the size, shape, and location of the stomach as a whole. Because of the emaciation, the abdominal walls are thin and through them the outlines of the stomach, filled either with gas or with fluid, are often distinctly seen.

Palpation shows a hard, usually irregular tumor mass, which may or may not be sharply circumscribed. It is usually tender on pressure, but not so much so as an ulcer. The mass is usually not movable, but may be so; even tumors of the pylorus, which one would expect to be always fixed, are sometimes very movable. It is often stated that tumors of the stomach do not move up and down with respiration, but it is certain that they do so frequently, even when not adherent to the liver, spleen, or diaphragm. This is true of cancer of the pylorus as well as of cancer of the body of the stomach.

Having demonstrated a tumor which might arise from the stomach, how shall we determine whether it does come from the stomach or not? Aside from the physical signs one must consider the subjective symptoms of the disease, and whether these point to a disease of the stomach or of some other organ, and must never forget that the cancer of the stomach is by far the most common tumor in this region, and in general, therefore, the diagnosis of a cancer of the stomach has a greater degree of probability than a diagnosis of some other tumor or some other point of origin than the stomach.

If a tumor always lies within the borders of the stomach dulness or tympany, according as the stomach is filled with fluid or with gas, the tumor arises from the stomach. If an area of tympany can be demonstrated between the tumor and the liver, the tumor does not arise from the liver and probably not from the gall bladder. Cancer of the gall bladder, because of its close anatomical relation to the pylorus, may be confused with cancer of the pylorus; but the symptoms of gastric disturbances, and especially the dilatation of the stomach almost always present with a cancer of the pylorus, are absent, and a history of biliary colic is often present.

Tumors of the spleen may be confused with tumors of the fundus of the stomach, but their regular outlines and oval shape, smooth surface, and extension up under the ribs, together with the absence of gastric symptoms, are usually sufficient to make the differentiation easy.

Tumors of the pancreas lie deeply in the abdomen, are not movable, and are apt to be accompanied by signs of compression of the common bile duct or the portal vein.

The following table from Boas' "Disease of the Stomach" shows the very important relations of tumors of this region to the distended stomach and colon:

	Inflation of Stomach.	Inflation of Colon.
Stomach.		
(a) pylorus	Displaced to the right and down.	Displaced upward.
(b) anterior wall and greater curvature.	Feel larger and borders less distinct.	Displaced upward.
(c) lesser curvature.	Disappear completely ..	Displaced upward.
Liver	Displaced upward and to the right, and borders of organ more easily palpable.	Displaced upward; tumors of gall bladder also forward: very large tumors may be unaffected.
Spleen	Displaced to the left and often downward also.	Displaced up and to the left.
Colon	Displaced down	Not displaced up.
Kidney	....	At first displaced up a little, then disappear backward. The movable kidney returns to place
Omentum	Displaced downward...	Displaced downward.
Pancreas	Disappear behind stomach.	

In some cases the development of secondary deposits in other organs is the first thing which proves the nature of the gastric process. For example, tumors of the liver are common in the course of cancer of the stomach, and because of their size they may distract the attention from the stomach and lead to an erroneous diagnosis of cancer of the liver, for here as elsewhere the secondary tumors may far exceed the primary in size. Another site for secondary deposits which may lead to a correct diagnosis of the primary disease, is a lymph gland just above or behind the inner end of the left clavicle. This gland is not infrequently the site of secondary cancer that has developed from cancer of the stomach.

Ulcer of the Stomach.—Ordinarily there is no need for differentiation between this disease and cancer of the stomach after demonstration of a tumor in connection with this organ, for this usually is proof of the existence of a cancer. Sometimes, however, a scar in the base of an ulcer or an hypertrophy of the neighboring muscular layer of the stomach may cause a palpable tumor. Under such circumstances differentiation is necessary and usually difficult. Attention must be given to the following points: Ulcer is a disease of the first half of life and is more common in women than in men. It causes a good deal of pain, which is much influenced by the taking of food. Generally the epigastrium is more tender from an ulcer than from a cancer. The course of an ulcer is longer, lasting even for many years. It causes hemorrhages which are usually more abundant than those caused by cancer. Ulcer causes a secondary anæmia, but not cachexia. Inasmuch as a tumor from cancer is common and from ulcer very uncommon, there must be very strong evidence in favor of an ulcer over a cancer, in any case in which a tumor in connection with the stomach is palpated.

Dilatation of the Stomach.—This often causes an easily visible, localized bulging of the abdomen in the region of the stomach. The stomach in such cases is often displaced downward, so that both the greater and the lesser curvature are visible. In many of these cases, notably those in which the dilatation of the stomach is due to pyloric stenosis, there are very manifest peristaltic movements of the stomach, exaggerated because the hypertrophied muscle layers of the stomach are trying to overcome the obstruction to the outflow of the stomach contents. The waves of motion pass from left to right. They may appear spontaneously or only after stimulation. Palpation of this bulging area gives a peculiar resistance and elicits both palpable and audible splashing, which, however, is not peculiar to gastrectasis, for it is found also in health, though not to the degree present when the stomach is dilated. Percussion of the stomach, both when filled with gas and when filled with fluid, is our most valuable means of determining the size and location of the stomach.

These physical findings, together with the history of gastric symptoms and the vomiting of large amounts of material—amounts far in excess of the normal capacity of the stomach—are enough to demonstrate the nature of the bulging of the epigastrium. The diagnosis of the cause of the dilatation of the stomach is a very different and a much more difficult problem.

Tumors of the Pancreas.

Practically the only diseases causing palpable tumors of the pancreas are the cancer and the cysts. It must, however, be remembered that when the abdominal walls are thin and relaxed, the head and even the body of the normal pancreas may sometimes be palpated. The pancreas lies deeply in the abdomen and is so attached that it does not show any respiratory or passive motility. Its anatomical relation to the transverse colon and its mesentery is such that tumors of the pancreas, when large enough to displace the colon, displace it downward, rarely directly forward, and almost never upward. This is often the most important fact in the differentiation of tumors of the pancreas from tumors arising from neighboring organs.

Cancer of the Pancreas.—This is a relatively rare condition, but is by far the most common disease of the pancreas. The symptoms consist of a combination of the effects of pressure upon the neighboring organs, of altera-

tions in the function of the pancreas, and, in about twenty to twenty-five per cent. of the cases, of the presence of a tumor. The character of the symptoms depends in part upon the portion of the pancreas affected. This is oftenest the head. There are, first, symptoms of gastro-intestinal disturbances, such as anorexia, dyspepsia, vomiting, and other manifestations of gastrectasis; fatty stools; often very large stools; pain, either constant or in the form of very severe colic; gradually developing and persistent jaundice, often with no increase or with only moderate increase in the size of the liver; marked distention of the gall bladder; ascites with enlargement of the spleen; and glycosuria in some cases.

When a tumor is palpable it lies deeply, varying greatly in size, but is smooth or irregular, not sharply outlined, and usually lies to the right of the median line. In most cases the tumor is fixed, and shows neither passive nor respiratory motility. Exceptions to this rule do occur, especially when the tumor is in the tail of the pancreas. Inflation of the colon shows it to lie below, *i.e.*, on the caudal side of the tumor. Because of the close relation to the aorta the tumor often seems to pulsate, but the pulsation is a mere up-and-down pulsation, not expansile. When ascites is present, paracentesis is often necessary before the tumor can be palpated.

The two most important symptoms are the icterus and the presence of a tumor. The icterus is chronic, gradually progressive, intense, and once established does not disappear. The tumor must be differentiated from tumors of other organs in this neighborhood. Cancer of the transverse colon is more superficial, is movable, is associated with difficult movements of the bowels, and is free from ascites and jaundice, as a rule; stools are not fatty. Cancer of the pylorus lies more superficially, is more movable, is accompanied by changes in the gastric secretions. It does not cause fatty stools and is less often associated with icterus and ascites.

Tumors of the duodenum and of the ductus choledochus are far more difficult, often impossible, to differentiate from tumors of the pancreas.

It is said that cachexia develops much earlier with cancer of the pancreas than with cancer of other organs, and is accompanied by more severe pain than in the case of cancer of a neighboring organ.

Cysts of the Pancreas.—The demonstration of a cyst is preceded by a longer or shorter period of obscure dyspeptic disturbances, pain and emaciation. The pain is either paroxysmal and colic-like or constant. The paroxysmal pains are said to occur with no other abdominal cyst than the pancreatic cyst. Disturbances in the bowel movements, fatty stools, icterus and ascites—in short, all of the symptoms of cancer of the pancreas except those resulting from the nature of the cancerous tumor—may appear.

The cysts usually cause some, maybe immense, enlargement of the abdomen, beginning usually in the epigastrium, but later it may sink lower in the abdomen. The surface is smooth, often fluctuating. Usually the cyst shows no motility, but it may in some cases. The stomach may lie above, in front of, or below the cyst. The same is true of the colon, but almost always the colon lies below, *i.e.*, to the caudal side of the cyst. Puncture of the cyst yields fluid varying greatly in character, and showing nothing absolutely peculiar except in those cases in which the pancreatic ferments are found in the fluid.

These cysts must be differentiated from other abdominal cysts, especially the echinococcus cysts, the hydronephrosis, and the ovarian cysts. The echinococcus cysts will be recognized by the demonstration of the hooklets and scolices in the fluid. Whether the cyst arises from the pancreas or from some other organ, is usually plain when the relation of the cyst to the colon is discovered. Ovarian and pancreatic cysts are often confused, but attention to the history, especially the early history, of the tumor, and to the portion of the abdomen where it first appeared, and to the relations between cyst and colon, will remove any doubt. If the fluid obtained by puncture shows pancreatic ferments, the cyst must be from the pancreas. The absence of these ferments does not prove that the cyst is not from the pancreas.

Hydronephrosis usually gives a history of urinary symptoms, renal colic, and lumbar pain, and an appearance of the tumor in the flanks. The colon lies in front of the hydronephrosis. Fluid from the hydronephrosis shows urea, sometimes uric acid, and may contain cells from the pelvis of the kidney. Catheterization of the ureters, or the collection of the urine which comes from each kidney separately, may assist.

Tumors of the Spleen

are of two sorts—diffuse splenic tumors, none of which are new growths in the ordinary use of this term, and localized tumors of the spleen. The former group is common, the latter quite uncommon. The diffuse splenic tumors, although due to widely varying pathological processes, have some peculiarities in common, *i.e.*, they retain the general shape of the normal organ. Even when greatly enlarged, the spleen retains its elliptical shape, with a notch in the lower part of the anterior border, and, though thickened, is still much greater in all dimensions than in thickness. The long axis of the spleen passes from the left above, downward and to the right, although in cases in which there is much enlargement the long axis is often more nearly parallel to the long axis of the body than is encountered in the normal individual. The enlarged spleen usually occupies the upper left-hand quadrant of the abdomen, but it may be displaced to any other portion, when it often occasions great difficulty in diagnosis.

The methods of examination are in general as outlined above, but many are inclined to place too much value upon percussion and too little upon palpation. The size of the splenic dulness may be decreased by the tympany of stomach or colon, or increased by dulness in either of these organs. In either case the percussion of the spleen is valueless. Palpation of the spleen is liable to fewer errors and should therefore be preferred. The patient should lie upon the back or obliquely upon the right side; the physician should stand upon the left of the patient, with the left hand making pressure forward over the lumbar region. The right hand should palpate from in front during both quiet and forced inspiration. A normal spleen, unless dislocated, cannot be palpated. Note the shape, size, firmness, tenderness, and motility of the organ. The shape, position, and motility of the organ are so peculiar that there is rarely any difficulty in recognizing that a splenic tumor is really what it is. In doubtful cases the relation of the tumor to the colon and the stomach should be ascertained by distention of these organs with gas. The spleen lies external to the stomach, above and in front of the colon. It is very rarely that the colon passes in front of the spleen.

Auscultation of the spleen rarely gives any results, but sometimes one hears venous hums similar to those heard in the large veins of the neck. In cases of perisplenitis one sometimes finds localized friction.

Exploratory puncture of the spleen is at times a valuable aid, but is not entirely free from difficulties and dangers.

Acute splenic tumors are seen in a very wide range of acute infectious diseases; in fact, there is no one of these diseases which may not cause acute swelling of the spleen. Certain of them, like typhoid fever and malaria, do so with such constancy that the want of the splenic tumor throws some doubt on the correctness of the diagnosis. Such enlargements of the spleen develop rapidly and present the shape and motility of the normal spleen. The degree of enlargement varies, but may be very considerable. Usually there is no tenderness and the spleen feels soft, but there are marked exceptions to this rule. The diagnosis of the site of the tumor is made by attention to the position and shape of the tumor. The nature of the tumor will be recognized when the general febrile disease, of which the splenic tumor is a symptom, is recognized.

Chronic enlargements of the spleen occur as a result of certain of the chronic infectious diseases, notably malaria.

Abdominal Tumors.

The malarial spleen, or so-called ague-cake, is seen frequently in certain regions where opportunities for malarial infection are constantly present. In such regions the condition is well known and readily recognized, but in other sections where malaria is exceptional the malarial spleen may be taken for other conditions. It presents the characteristic form, is hard, and may attain almost any size, not infrequently reaching to or even beyond the umbilicus. The nature of the enlargement is recognized by a history of prolonged malarial infection and by the exclusion of other causes of enlargement of the spleen. Examination of the blood for the malarial organisms is usually futile, for the splenic tumor may continue for many years after the infection has subsided.

Syphilis, either the tertiary stage of the acquired or the hereditary syphilis, may cause chronic splenic tumors, the true nature of which can be learned only by attention to the history.

Cirrhosis of the liver, either the atrophic or the hypertrophic form, causes a chronic enlargement of the spleen which does not differ in any way from other chronic splenic tumors, and its nature can be ascertained by recognition of the hepatic condition of which the splenic tumor is a symptom. In general the spleen is larger with the hypertrophic than with the atrophic form. The enlarged liver, the jaundice either actually present or repeatedly present in the history, the prolonged freedom from circulatory disturbances, together with the enlarged spleen, make a clinical picture not easily mistaken. The small liver, the collateral circulation upon the abdomen, the ascites, and the enlarged spleen make up the cardinal symptoms of the atrophic cirrhosis.

Amyloid Spleen.—The enlargement is similar to the other diffuse enlargements of the spleen. The essential points in the diagnosis of the nature of the process are the same as those given under the heading Amyloid Liver.

Passive congestion of the spleen occurs when the outflow of blood is obstructed. The commonest cause of this is the atrophic cirrhosis of the liver. Less often it is due to compression of the veins outside the liver by tumors or adhesions. Sometimes the spleen is enlarged from obstruction above the diaphragm, oftenest from cardiac insufficiency.

Leukæmia.—All the enlargements of the spleen so far considered have been merely symptoms of disease elsewhere in the body, and the diagnosis of the nature of the splenic tumor has been based on the recognition of the primary disease; but the leukæmic spleen is of a different class, for it constitutes an integral part of the disease. The enlargement presents no peculiarities which will enable one to distinguish it from other diffuse processes in the spleen except for the size often attained by the leukæmic spleen. It often extends to the median line and downward to the ilium; cases even larger than this are not uncommon. The liver is often but not always enlarged, and when it occurs the increase in size is uniform. The lymph glands throughout the body are often enlarged, but in many cases not. The participation of the bone marrow in the leukæmic process may be shown by tenderness or pain over the bones, but the lack of these symptoms does not mean that the medulla has escaped.

The symptom upon which the diagnosis of a leukæmia rests is the change in the blood. The blood should be examined in all cases in which the spleen is found enlarged and in all cases in which an abdominal tumor found may by any possibility involve the spleen. The characteristic blood changes consist in a marked increase in the number of white cells, while at the same time the relative percentage of the different forms of white blood corpuscles is altered. There is an absolute increase in the number of all forms, but the polymorphonuclear form is relatively decreased in number often far below the normal average of eighty per cent.; the lymphocytes, myelocytes, and eosinophile cells are relatively, as well as absolutely, increased. The degree of increase of each form differs in the different cases and in the different forms of leukæmia. It is at once evident that these blood changes differ widely from the leucocytosis in which the absolute increase in the number of white blood cells may reach as high a figure as in leukæmia, but in the leucocytosis the polymorphonuclear leucocyte is the form increased in number, and this increase is both absolute and relative.

The changes in the number of red blood corpuscles and the percentage of hæmoglobin are in no way peculiar.

The blood changes described are peculiar to leukæmia, and upon them alone the diagnosis of leukæmia must be based.

Pseudo-leukæmia causes an enlargement of the spleen which is uniform and often extreme in degree. Ordinarily the diagnosis is not difficult, for the changes in the spleen are accompanied by similar changes in the lymph glands generally and in the liver, thus showing that the splenic tumor is merely a part of a constitutional disease. The diagnosis becomes more difficult when the case is one of splenic pseudo-leukæmia, *i.e.*, one in which the spleen alone is grossly changed. There are no characteristic blood changes in this disease, the blood showing only the findings of a severe anæmia. The red blood corpuscles and hæmoglobin are greatly decreased, but the color index is less than one. There is no leucocytosis. There is often a temperature of the chronic recurrent type.

When the lymph glands generally are enlarged the diagnosis is usually simple. Leukæmia is excluded by an examination of the blood. Generalized tuberculosis of the lymph glands is not so readily excluded, but this is a very rare disease, while the pseudo-leukæmia is not. In the cases in which the spleen alone is enlarged the diagnosis must be reached by exclusion of all other possible causes for splenic enlargement in a case presenting a progressive anæmia. Especial care must be taken to exclude the chronic splenic tumor due to an old malaria.

Chlorosis and pernicious anæmia are sometimes associated with enlargement of the spleen. This is only moderate in degree and is so insignificant when compared with the manifest blood changes that it is often overlooked.

During the course of diseases which may cause emboli, such as endocarditis, aortitis, and the like, one sometimes finds a painful and tender enlargement of the spleen suddenly developed. It is often accompanied by vomiting and chill. These are the symptoms of an infarction of the spleen, and if the embolus is simple they all disappear in a short time; but if the embolus is septic other symptoms soon appear. There are repeated chills with irregular temperature, sweating, and emaciation—in short, the constitutional disturbances common to suppurative processes anywhere in the body. The spleen increases in size, perisplenitis with friction appears in many cases, and sometimes we find fluctuation and changes in the abdominal wall, such as redness, œdema, etc. When the abscess of the spleen is large, it often pushes the diaphragm high up into the thorax, giving signs which may easily be mistaken for pleurisy with effusion. The upper border of the dulness differs in shape from that ordinarily assumed by pleural effusions, and the respiratory excursion is greater, even though less than normal. Exploratory puncture shows the presence of pus.

Neoplasms of the spleen are rare and are difficult to differentiate from simple hypertrophy of the spleen. They may be suspected when the enlargement of the spleen is irregular and nodular. When such a splenic enlargement is found, tuberculosis, syphilis, carcinoma, and sarcoma must be considered. If the individual is tuberculous, the spleen is probably tuberculous; if he is syphilitic, it is probably a gumma. If there is a carcinoma of some other organ, such as the stomach or pancreas, for example, it is probably a secondary carcinoma. If no other explanation is manifest, it may be a sarcoma.

Echinococcus cysts occur in the spleen, causing an enlargement which may be very great. The disease causes no peculiar constitutional disturbances, and the true nature of the process can be learned only by exploratory puncture and the demonstration of hooklets and scolices.

Wandering Spleen.—Because of the lengthening of its ligaments the spleen may become very movable and be found anywhere in the abdomen, although as a rule it does not descend below the umbilicus. It retains its nor-

nal oval shape with one or more notches in the anterior border. The size is often considerably increased because of congestion. Sometimes the pulsations of the splenic artery are felt at the hilus. Percussion shows the absence of the splenic dulness in the normal site, but when the spleen is pushed back into the left hypochondrium, as can be done easily in most cases, the splenic dulness reappears. The peculiar shape, the extreme motility, and the presence of tympany in the normal site of the splenic dulness are usually enough to enable one to make the diagnosis. A mass of fæces in the splenic flexure of the colon may give an area of dulness similar in site, size, and shape to the splenic dulness, but any confusion of this sort is avoided by clearing the bowels, as should be done before examination of any obscure abdominal tumor. Other very motile tumors, when about the size and shape of the spleen, such as tumors of the intestines, wandering kidney, movable tumors of the pylorus, may be taken for a movable spleen, but the fact that there is an area of dulness in the splenic region, no matter where the tumor is, will exclude a movable spleen. The difficulties of diagnosis are sometimes increased by the spleen becoming fixed in the spot to which it has been dislocated.

Tumors of the Kidney.

The normal kidney cannot be palpated unless it happens to be displaced, a condition which is far more common than is generally supposed. If palpation is employed it is best to use both hands; the patient lying first on the back and then on the side. In making such an examination one must remember that there are various pathological processes which cause enlargement of the kidney. The diagnostician must therefore not only establish the fact that the tumor arises from the kidney, but he must also ascertain what is the nature of the underlying pathological process.

Tumors of the kidney usually cause first a fulness and bulging of the lumbar region and lateral abdominal regions. There is often a visible fulness behind. When enlarging, the kidney almost always pushes the colon and intestines forward and inward toward the median line. Their peristaltic movements are often visible in front of the tumor mass. The inner borders of the tumor may plainly be seen through the abdominal walls. Enlarged and tortuous subcutaneous veins are often visible. Pulsation can rarely be seen, and the movements caused by respiration are exceptional.

The size, consistency, and character of surface vary with the nature and duration of the process. Fluctuation is not uncommon. The vermicular movements of the intestines can sometimes be felt in front of the tumor. One may be able to insert the fingers between the tumor and the arch of the ribs, or outline the liver or spleen separately from the kidney.

Percussion is important as showing the relation of the tumor to the colon, which must often be inflated with air or gas before one makes percussion. It is also valuable in differentiating a tumor of the kidney from one of the liver or spleen. If there is an area of tympany between the tumor and the liver or spleen, the tumor does not arise from either of these organs.

Auscultation over renal tumors shows in some cases murmurs exactly like the hum heard over an aneurism.

If palpation has shown fluctuating areas in the tumor or if it is suspected that fluid is present in the mass, exploratory puncture can be made. This is not entirely without danger, but if the puncture is made from behind or well around on the side where one cannot enter the peritoneal cavity, the danger is minimal. Any fluid obtained will be found to vary with the pathological process, and may be urine, blood, pus, echinococcus fluid, etc. Sometimes small particles of the tumor may be obtained in this way and identified.

The principal tumors that require to be differentiated from tumors of the kidney are tumors of the liver, spleen, ovaries, gall bladder, suprarenals, and perirenal connective tissue.

Tumors of the right kidney differ from those of the liver in the following respects: There is often, in the case of the former tumors, an area of tympany between the two areas of dulness—that due to the liver and that due to the tumor. Then again, in renal tumors the fingers can often be pushed in between the ribs and the tumor, whereas this cannot be done when the tumor originates from the liver. Renal tumors show little or no respiratory motility, while hepatic tumors move freely during respiration. Renal tumors lie behind the tympanitic area of the colon, while those of the liver lie in front of or above this area. Renal tumors may cause a slight displacement upward of the upper border of the hepatic dulness, but this is the only change which they can effect in this area. Hepatic tumors, on the other hand, often cause the normally straight course of the border of hepatic dulness to become irregularly curved.

It is often most important to obtain the urine of each kidney separately. This is a difficult procedure, especially in the male. In the case of a female it is not very difficult, by use of a cystoscope, to catheterize the ureters and thus obtain the unmixed urine, but in the case of a male this is almost impossible, and the more successful method is to employ a Harris instrument. This is so constructed as to raise a ridge in the floor of the bladder between the two ureteral openings, thus making two separate pouches for the reception of the urine from each kidney. The urine is drawn from these pouches before they are entirely filled, and thus the urine of each kidney is obtained unmixed. The successful employment of this instrument requires some skill and practice; the procedure is infinitely easier to carry out than is the catheterization of the ureters. The same instrument may be used equally well in examining females.

Hydrops of the gall bladder may sometimes be confused with a movable kidney, but its pear-like shape, its superficial location anterior to the colon, and the fact that it cannot be pushed into the normal location of the kidney are usually sufficient to enable one to differentiate the two conditions.

Tumors of the spleen differ from tumors of the left kidney in the same ways as do the liver tumors from those of the right kidney. Then, in addition, splenic tumors, as stated elsewhere, retain the shape of the normal spleen.

Cysts of the ovaries rise from below upward instead of descending from above downward, and bear quite different relations to the colon. They lie within instead of without the circle of the colon, and in front of instead of behind the intestines, as the renal tumors do.

Attention to these physical differences in the tumors and due consideration of the accompanying symptoms will almost always enable one to differentiate correctly between the different conditions. Differentiation between suprarenal and perirenal tumors and tumors of the kidney is practically impossible unless changes in the urine are present. If these are found and are of such a nature as is compatible with a renal tumor, the adrenal and perirenal tumors may be excluded. Very high blood pressure with normal urine is sometimes seen with suprarenal tumors.

A diagnosis of the nature of a tumor recognized as renal depends more upon the accompanying symptoms than upon the physical characteristics of the mass.

Hydronephrosis.—In addition to the tumor, which is essential to the recognition of a hydronephrosis, we find alterations in the composition of the urine and in the quantity excreted. The amount of the urine varies greatly, being normal in cases in which only one kidney is affected while the other is normal, and in other cases varying from anuria to continuous or intermittent polyuria. The intermittent polyuria or anuria, especially when accompanied by a corresponding variation in the size of the kidney, is characteristic. The urine may be normal or it may be mixed with pus, blood, renal elements, and crystals, especially of uric acid. Exploratory puncture of the hydronephrosis yields fluid of varying character according as we have normal or pathological urine. The presence of urea and uric acid in the

fluid speaks strongly for a hydronephrosis but not positively, for these substances are found in the fluid contents of other cysts—the ovarian cysts, for example—and may be absent in the fluid of hydronephrosis.

The recognition of a possible cause for a hydronephrosis is always an important item in the diagnosis. Thus, a nephrolithiasis, a movable kidney, a tumor in the abdomen or pelvis which might compress one or both ureters, a bladder tumor, an enlarged prostate, or a urethral stricture, in a case which might be a hydronephrosis, is a fact which strongly favors this diagnosis.

The differentiation between hydronephrosis and ovarian cysts has been sufficiently considered. The presence of echinococcus hooklets or scolices in the aspirated fluid would prove the existence of an echinococcus cyst. The differentiation between a cystic kidney and a hydronephrosis is often impossible. The absence of a demonstrable cause would speak against the hydronephrosis. Early life speaks for the cystic kidney.

Pyelonephritis.—The important symptoms in this disease are alterations in the character and quantity of the urine, pain and other signs of local inflammation, tumor, and the constitutional disturbances of suppuration. The quantity of the urine varies from complete anuria to polyuria, the latter being the more common. The urine contains in varying quantities blood, mucus, pus, crystals, bacteria, sometimes bits of kidney tissue, sometimes casts. Albumin is always present, the specific gravity is lowered, and the reaction varies from acid to alkaline. Catheterization of the ureters or the separate collection of the urine is a valuable aid in the diagnosis, especially if carried out early in the course of a unilateral pyelonephritis. Exploratory puncture is an aid, but it is not often necessary and is more dangerous in this than in other renal affections.

Peri- and Paranephritis.—The important symptoms of these processes are the local pain, fever, and tumor. Of these the tumor is the most important, but requires time for its development, during which pain and elevated temperature are present, but do not make a diagnosis possible. The tumor increases steadily, often rapidly, in size and presents the characteristics of tumors of inflammatory origin. It is painful, tender, usually not sharply defined, is not movable, often fluctuates, and when sufficiently superficial is accompanied by an œdema of the skin. The urine is not changed by a primary paranephritis, but when the latter is secondary to suppurative processes in the kidney, as it often is, the urine shows changes because of the primary process.

The rules given for the differentiation of renal tumors from tumors of neighboring organs apply here also, so far as the localization of the process is concerned. The nature of the process is usually at once apparent from the combination of the local and constitutional disturbances of inflammatory origin. If there is still doubt, an exploratory puncture, by demonstrating the presence of pus, will settle the question. It is often difficult or impossible to learn whether the paranephritis is primary or secondary, but the chances are very decidedly in favor of the latter as a rule. If the urine contains pus, a pyelonephritis is probably the primary process. The paranephritis may be secondary to appendicitis, parametritis, or some other suppurative process in this region. Sometimes the gravitation abscess from a tuberculous spine is taken for a paranephritis, but usually an examination of the spine and the nervous system will enable one to make the differentiation readily.

Tuberculosis of the Kidney (Chronic).—The most important symptoms are the changes in the urine, the pain, and the tumor. The urine contains blood, pus, mucus, and cells in varying amounts. The pain is in the region of the kidney, but may radiate to the bladder, to the genitalia, and to the thigh. Sometimes the pain is distinctly that of a renal colic. The tumor presents the usual characteristics and relations of a renal tumor.

The diagnosis rests not on these symptoms, but upon the demonstration of tubercle bacilli in the urine or in the pus obtained by exploratory puncture of the tumor. This demonstration requires much patience, but it has been rendered decidedly easier by the introduction of the centrifugal machine. Another important item in the diagnosis is the demonstration of tuberculosis in some other organ, especially one of the sexual organs.

The tuberculosis of the kidney must be differentiated from nephrolithiasis and carcinoma of the kidney, both of which cause hæmaturia, pain, and renal tumor. The absence of renal colic, and of gravel in the urine, together with the presence of evening fever and of tuberculosis in some other organ, usually excludes the renal calculus. The absence of cachexia and leucocytosis and the presence of pus in the urine exclude the cancer. In cases which are still doubtful, an injection of the Koch tuberculin, by exciting a violent reaction, will remove all doubt. The important question as to whether one or both kidneys are tuberculous may require cystoscopic examination or the collection of the urine from each kidney separately.

Carcinoma and Sarcoma of the Kidney.—These will be considered together, for the clinical differentiation between them is never certain, and practically it is a small matter whether the tumor is carcinoma or sarcoma. Here again we find the combination of pain, hæmaturia, and tumor. The pain appears early, as a rule, but is in no way peculiar. The hæmaturia is present in about one-half of the cases, and may be an early symptom or it may be delayed until late in the course. It differs greatly in amount and frequency in the individual cases. The tumor resembles the other tumors of the kidney, but in some cases it presents an expansile pulsation and hum exactly like those of an aneurism. Cachexia and anæmia with leucocytosis appear sooner or later. The diagnosis is based mainly upon the exclusion of other renal tumors, the absence of fever, and the presence of cachexia. Both carcinoma and sarcoma are especially common in young children, at which time of life tumors such as hydro- and pyonephrosis and tuberculosis are exceptional. In adults the differentiation is more difficult and errors are not infrequent.

Other forms of renal tumors, such as the cystic kidneys, fibroma, lipoma, myoma, etc., need no consideration here.

Movable Kidney.—This is one of the most common pathological conditions affecting the kidney, and it renders a kidney otherwise normal easily palpable. In a large percentage of the cases there are no subjective symptoms, and the condition is discovered accidentally during an examination made for some other purpose. In some cases there are subjective symptoms which vary greatly in the individual cases. These are: pain of varying character and site, gastro-intestinal symptoms, symptoms due to pressure upon gall duct or intestinal tract, periodical hydronephrosis. These symptoms occur in many combinations and degrees and present nothing characteristic.

The diagnosis must be made by the palpation of the kidney. Usually the peculiar bean shape of this organ is readily recognized. The hilus can be located and sometimes the renal artery palpated. The kidney feels smooth, firm, and of a normal size in most cases. It is not especially tender, but when it is firmly compressed a peculiar sickening pain is produced. The degree of motility varies from a minimal amount which just permits palpation of the lower pole of the kidney, to such an amount that the kidney can be displaced beyond the median line. In most cases the kidney can readily be returned to its normal location. In some cases the movable kidney comes to lie within the circle of the colon, and, when it is fixed here, the diagnosis is a very difficult matter. As a rule, however, the diagnosis is easily made.

The characteristic shape and size of the tumor and the ease with which it can be returned to the normal location of the kidney furnish sufficient evidence. Sometimes highly movable tumors of the intestines, omentum, gall bladder, and pylorus, when their size is about the same as that of the kidney, are mistaken for a movable kidney, but usually attention to the history, to the subjective and objective symptoms, and especially to the relations of the tumor to the colon, will remove all doubt. Some-

times it is rather difficult to distinguish between a movable kidney and a tongue-like projection of the right lobe of the liver. Such a projection is often quite freely movable, so that it can be pushed backward into the location of the kidney. Usually, however, it has a different shape, and careful palpation will show it to be in connection with the liver. The colon lies behind instead of in front of it. Sometimes differentiation is aided by the demonstration of the kidney in its normal location. This may be done by percussion of the back, which procedure shows a small area of dulness on each side of the spine, continuous above with the liver or spleen dulness and bordering externally upon the tympanitic area of the colon.

Tumors of the Small Intestines.

These tumors are rare, but almost any kind of tumor may appear in connection with the intestines. The symptoms, which are mainly those of more or less complete intestinal obstruction, vary somewhat with the site of the tumor. The commonest tumor of the small intestines is carcinoma of the duodenum. This causes the anæmia and cachexia which commonly accompany all carcinomata, and at the same time pain in the right hypochondriac region. In favorable cases a tumor develops deeply in the abdomen and shows only slight motility or none whatever. Because of the obstruction to the onward movement of the intestinal contents gastric symptoms due to dilatation of the stomach are prominent. When, as may easily happen, the common duct or at least its orifice is narrowed, we find jaundice and the results of lack of the pancreatic digestion. Ascites may result from compression of the portal vein.

When the tumor is situated lower down in the jejunum or ileum, the gastric symptoms, jaundice, and ascites are less common, and we find the symptoms of gradually increasing intestinal obstruction. The tumor when felt is characterized by extreme motility. The lower the tumor the more marked the effect upon the bowel movements and the more easily blood, pus, and the like appear in the fæces. The lower the tumor the greater the distention of the abdomen with gas and material accumulated above the tumor. The collection of the gas is centrally located in the neighborhood of the umbilicus.

It is only in rare cases that the intestinal crises of locomotor ataxia cause localized spasms of the intestinal walls, and give rise to hard masses that may easily be mistaken for multiple tumors. However, if the other symptoms of tabes are carefully sought for, it is not likely that an error in diagnosis will be made.

When the small intestines are filled with gas, and especially when onward movement of the gas is prevented by an obstruction of any sort, such as an intussusception, volvulus, or internal strangulation, they are often visible as tumors. They differ from other tumors in their spontaneous motions, which in these cases are exaggerated beyond the normal, even to the point of being felt as well as seen. In some cases of intussusception the invaginated portion of the small intestines can be felt as a sausage-shaped, motile tumor. Such visible peristalsis is often an aid to diagnosis in cases in which other symptoms point to an intestinal obstruction.

When the amount of gas is very large, the abdomen as a whole is greatly swollen, the skin being tense and shining, and often showing the blue veins through. The general appearance is like that of ascites, but percussion will at once show the difference. The shape of the abdomen differs somewhat from that observed in ascites, for the anterior portion about the umbilicus bulges prominently, while in ascites this part is flattened and the flanks bulge. The degree of distention depends mainly upon the amount of the gas, but in part also upon the tone of the intestinal walls. If this is lessened, as by a generalized peritonitis, the distention is much greater. The liver and spleen with the diaphragm are pushed upward, thus displacing the heart and lower pulmonary borders. The area of dulness corresponding to the liver may be obscured by the intestines rising over this organ in front.

Aneurism of the Abdominal Aorta or Its Branches.

In emaciated individuals the abdominal aorta may often be felt, and its pulsation is occasionally visible. This visible pulsation, however, must not be interpreted as indicating the existence of an abdominal aneurism, unless an expansile tumor is found. The indications that such an aneurism exists vary with the site and size of the tumor. They consist in part of pressure symptoms and in part of the physical signs of an aneurism. The pressure symptoms are too numerous to mention, for any organ or nerve in the abdomen may be compressed. The essential and peculiar characteristic of these tumors is the expansile pulsation. No other tumor shows this except under extraordinary conditions. Solid tumors about large vessels—for example, tumors of the retroperitoneal lymph glands—sometimes show expansile pulsations and may for this reason be mistaken for aneurisms. Very vascular neoplasms may show pulsation and murmurs. Motile spherical tumors resting upon large vessels often show a transmitted pulsation, which, upon careless examination, may be mistaken for an expansile pulsation. The auscultation of abdominal aneurisms is of less value than might be expected, for murmurs in the abdominal vessels, both veins and arteries, are not uncommon. Aneurisms of the aorta itself lie to the left of the median line and because of their deep location often enlarge backward, thus causing bulging and pulsation posteriorly. Because of the close relation of the aneurism to the nerves of the lumbar plexus, symptoms of pressure on the nerves (neuralgia, anæsthesia, paralyses) are often early and prominent symptoms. Aneurisms of the cœliac axis tend to enlarge forward, and because of their close relation to the vena portæ they often cause jaundice and ascites.

Tumors of the Retroperitoneal Lymph Glands

occur both as primary and as secondary processes. There may be several small tumors or one or more large ones. They present the usual characteristics of tumors of lymph glands, being round or egg shaped in some cases, and somewhat nodular in others. They lie deep in the abdomen, behind the intestines, and show neither passive nor respiratory motility. When resting on the aorta they may show a transmitted pulsation, or when surrounding it they may show even an expansile pulsation.

There are numerous pathological processes which can cause such enlargements of the retroperitoneal lymph glands, viz., tuberculosis, leukæmia, pseudoleukæmia, and lymphosarcoma. They may represent metastases from malignant tumors located elsewhere in the body. The diagnosis of the nature of the tumor is based mainly upon a consideration of the history and upon the constitutional disturbances which may be present. The absence of anything pointing to disease of other organs in the abdomen often aids the physician in making a correct diagnosis. Finally, it may be found impossible to learn the exact situation and true nature of such glandular tumors except by means of an exploratory operation.

Tumors of the Peritoneum and Omentum.

These occur either in the form of a solid tumor (tuberculous, carcinomatous, or sarcomatous in its nature) or in that of a circumscribed exudate of one sort or another.

Tuberculous peritonitis shows itself in a variety of ways: it may cause diffuse enlargements of the abdomen, or localized fluid exudates, or separate tumor masses. The diffuse enlargements have been considered in the paragraphs upon ascites. The localized fluid exudates and the tumor masses may occur anywhere throughout the abdomen and may be single or multiple. It is usually more difficult to make a correct diagnosis when one such focus of disease is present than when there are several. Because of the fact of their varying locations nothing can be said as to their relations to the other abdominal organs. Either of the two conditions named may occur separately, but in many cases there is a more or less generalized affection of the peritoneum accompanied by a fluid exudate

which lies free in the peritoneal cavity and which is often sufficient in amount to cover up the localized process. When there is such a collection of fluid, sufficient should be withdrawn to enable one to determine its character. If it is an exudate, as shown by its high specific gravity and percentage of albumin, the case is one of chronic peritonitis. In some cases, although not many, its tuberculous nature can be shown by the demonstration of the tubercle bacilli or by inoculation of a guinea-pig. In most cases, however, this fails, and the diagnosis must be made by a close scrutiny of the other organs of the body. The demonstration of a tuberculous process elsewhere in the body, as in the lungs, lymph glands, bones, or testicles, speaks strongly for the tuberculous nature of the process in the abdominal cavity. A coincident inflammation of one or more other serous surfaces, such as the pleura or pericardium, also speaks for the tuberculous nature of the process. The absence of symptoms pointing to carcinoma of any organ, especially any organ in the abdomen, such as the stomach, uterus, or rectum, is an additional fact in favor of the tuberculous nature of the chronic peritonitis.

In some doubtful cases the tuberculin test may aid. A positive reaction in the absence of manifest tuberculosis in some other part of the body, speaks strongly for the tuberculous nature of the abdominal process, but the absence of the reaction does not exclude tuberculosis. The blood should be examined, and the absence of any increase in the number of leucocytes speaks for tuberculosis, because it speaks against the other common cause for chronic peritonitis, viz., the neoplasms.

Tuberculosis affecting the omentum often causes it to shrink up into an elongated, sausage-shaped tumor lying transversely across the upper part of the abdomen. Such a tumor is so peculiar that its origin is at once manifest, but other processes than the tuberculosis can cause the same deformity of the omentum. Attention to the points mentioned above and the exclusion of cancer of the organs commonly affected will usually establish the nature of the tumor.

Localized fluid tuberculous exudates have often been mistaken for ovarian cysts even by experienced observers, but attention to the points given above, especially to the character of the fluid obtained on aspiration, will usually make the correct diagnosis possible.

Localized suppurative processes in the abdomen, such as an appendicular abscess, often produce a well defined tumor. The accompanying constitutional symptoms—irregular fever, chills, sweating, leucocytosis, etc.—together with the local pain and tenderness, are usually sufficient to show the nature of the process, and careful attention to the history will show the probable point of origin. Such abscesses may occur anywhere in the abdomen, but there are certain sites of predilection. For example, they are common in the neighborhood of the appendix, but the appendicitis can cause abscesses in other parts of the abdomen remote from the appendix. They also often arise from various infective processes in the female genitalia. Perforating ulcers, especially those of the stomach and duodenum, may also furnish a considerable number of these cases. Infective processes in the liver and bile passages do the same thing.

Neoplasms of the peritoneum are far more frequently secondary than primary. They are oftenest secondary to carcinoma of the abdominal viscera, but the primary tumor may be remote, as in the breast. The clinical manifestations are almost exactly the same as those of tuberculous peritonitis—viz., vomiting, hiccough, and intestinal disturbances—together with the development of tumor masses, usually multiple and often accompanied by large amounts of fluid exudate, either lying perfectly free in the peritoneal cavity or partially encapsulated. The effects on the omentum are often exactly like those produced by tuberculosis. The fluid obtained by puncture has the characteristics of an exudate, is often hemorrhagic, and may be fatty. In these respects it is exactly like the tuberculous exudate. It never contains tubercle bacilli and does not excite tuberculous peritonitis in the guinea pig, but sometimes it contains cancer cells either singly or in groups.

If the primary tumor is discovered, the diagnosis of the nature of the process is easily made. When no such tumor can be found, the diagnosis will rest upon the exclusion of tuberculous peritonitis.

Other peritoneal tumors, such as lipoma, fibroma, cysts of the mesentery, and chylous cysts, are so rare that they need no consideration, and, in fact, are seldom diagnosed except by the aid of an exploratory laparotomy.

Tumors of the Bladder.

The true neoplasms of the bladder are quite rare and they do not cause palpable abdominal tumors. There is practically only one condition which renders the bladder palpable, and that is the retention of urine. This causes a long oval tumor which rises upward from the pelvis to almost any height, even beyond the umbilicus. It is rounded, smooth, tense, and usually not tender. It lies as a rule exactly in the median line and is dull on percussion. The patient may or may not pass any urine.

The diagnosis is manifest when the patient is passing no urine, but it is not always so clear when the urine is constantly dribbling away. The introduction of a catheter and the disappearance of the tumor upon the withdrawal of the urine make the diagnosis plain The discovery of the cause of the retention is a different problem.

Ilio-psoas Abscess.

This variety of abscess appears as a tumor on one side of the spine or in the iliac fossa. Its size and shape vary greatly. It lies deeply behind the intestines. It is painful and tender, but not to an extreme degree, for most of these abscesses are of tuberculous nature. The thigh is flexed and rotated outward. Usually the nature of such abscesses is at once manifest because of the deformity of the spine and of the disturbances in the function of the spinal cord. This, however, is not always so, and therefore whenever an abscess is found in this region, or, for that matter, in any region in which such a gravitation abscess may occur, the spine and the areas supplied by the spinal nerves should be carefully examined. Such an examination will exclude the appendicular abscesses or an abscess arising in this region secondary to suppuration in the pelvis.

Tumors of the Uterus.

There is usually not much difficulty in recognizing a tumor of the uterus as such Its situation low down in the median line, its evident origin in the pelvis, the ease with which motion is transmitted from the tumor to the cervix, and *vice versa*,—these, together with the alterations in the genital functions usually found, are sufficient in most instances to show that the tumor does arise from the uterus. A diagnosis of the nature of the tumor is a far more difficult matter, and even the most expert often err in their judgment as to the nature of a tumor which plainly arises from the uterus.

Pregnancy.—This causes a progressive enlargement of the uterus, and it has been a fruitful source of errors in diagnosis. The resulting tumor is smooth, round, and not tender; menstruation ceases; the breasts undergo changes; and in course of time the fœtal heart tones and movements appear. The commonest difficulty is that of distinguishing pregnancy from uterine fibromata. These cause enlargement of the uterus, often associated with irregularity in the menstruation, less often with cessation of this function. The enlargement of the uterus is not so symmetrical as it is in pregnancy, and the rate of growth is not so rapid. In pregnancy the size of the tumor shows a nearly constant relation to the duration of the period during which menstruation ceases. It is not permissible, under these conditions, to resort to a measurement of the uterine cavity by means of the uterine probe. The diagnosis becomes still more difficult when the two conditions (pregnancy and a tumor) are com-

bined, but attention to the shape of the uterus, the rate of enlargement, and the ordinary signs of pregnancy will usually enable one to arrive at a correct conclusion. If any doubt remains, the diagnosis must be reserved until the time arrives for the appearance of the sure signs of pregnancy.

When the pregnancy occurs in one horn of a bicornate uterus, the resulting tumor differs so much from the ordinary tumor of pregnancy that error may arise. The usual symptoms of pregnancy are present, and the diagnosis of pregnancy can be made as early here as in a normal case. Careful bimanual examination will usually make the correct diagnosis possible. Such a tumor may be taken for an ovarian tumor. Ovarian tumors, however, are usually farther removed from the median line; there is no relation between their size and the duration of the disturbances; the signs of pregnancy are usually entirely absent; and the motion of the tumor is not transmitted so completely to the cervix.

Fibroid Tumors of the Uterus.—These are very common, especially in women past the middle point of life. They cause a greater or less increase in the size of the uterus, which may even reach such a bulk as to occupy the main portion of the abdomen. They cause irregular and often profuse uterine hemorrhages, and are associated with irritability of the bladder and rectum, with pain in the pelvis and legs, and often with œdema of the latter. The enlargement of the uterus is usually very grossly irregular and nodular. The tumors feel hard, and in rare cases they may, from cystic degeneration, yield fluctuation. They vary greatly in size and shape, being often sessile or hemispherical. Sometimes they are pedunculated and show considerable passive motility. The uterine cavity is lengthened and irregular. These tumors lie in front of the colon, sigmoid, and small intestines.

In cases such as we are now considering, the diagnosis is difficult only when the tumors are so small that they cannot be felt from above. The main point of differentiation between the fibromata and pregnancy have been already mentioned. In the case of movable, subperitoneal, and pedunculated tumors of the uterus, the diagnosis is sometimes quite difficult, especially when the tumor is single. Fortunately this is exceptional. Such movable tumors may be taken for an ovarian cyst, for a movable kidney, or for a tumor of the intestines, but attention to the history and a careful examination will enable the physician to distinguish between them.

Cancer of the Uterus.—The primary uterine tumor rarely attains sufficient size to present itself as an abdominal tumor, and in these rare instances the condition of the patient is such that the diagnosis is manifest from the cachexia, anæmia, and profuse, fetid, bloody vaginal discharge. The metastases of uterine carcinoma frequently present themselves as abdominal tumors of either the liver, the peritoneum, or the lymph glands, and since the secondary tumor may far exceed the primary tumor in size, these metastases may be mistaken for primary tumors. It is therefore wise to examine the uterus in all cases of abdominal tumors of obscure origin. If such tumors may by any possibility be secondary to a uterine carcinoma, and the uterus is found enlarged, or a fetid discharge without enlargement of the uterus is found, scrapings from the uterus should be examined microscopically.

Retention of Menstrual Fluids.—This may cause very great enlargement of the uterus. The diagnosis is usually simple. The cervix is found obliterated, there is no menstrual flow, but the patient suffers at regular intervals from the other symptoms of menstruation.

Ovarian Cysts.

The diagnosis of this common disease of the ovary is based almost entirely upon the results of physical examination, for such cysts bring about no characteristic alteration in the function of the genitalia. Cysts which are so small that they remain within the pelvis do not call for any special consideration in this place.

Confusion between an ovarian cyst and such conditions as collections of gas in the intestines, an over-distended bladder, accumulations of fæces in the colon, pregnancy, fat abdominal walls, and moderate-sized collections of free fluid in the abdomen can persist only when the examination is incomplete. Careful palpation, percussion, and auscultation in a patient properly prepared for examination by complete evacuation of the bladder and rectum will prevent such errors. The differentiation between ovarian cysts and localized collections of fluid in the abdomen, cysts of other organs in the abdomen, and certain tumors of the uterus is far more difficult, and sometimes is impossible without exploratory incision.

Encysted peritoneal exudates, usually of a tuberculous or carcinomatous origin, may very closely resemble the ovarian cyst. In many of these cases the results of the physical examination are such as to fit as well with one condition as with the other, but in general the outlines of the ovarian cysts are sharper and more distinct, and the tumors themselves are often more motile in response to the changing position of the patient. Usually there is no fluid free in the peritoneal cavity, in the case of an ovarian cyst, while this is quite common in both the tuberculous and the carcinomatous varieties of peritonitis. In many cases light may be obtained from other sources—the history of the case, the body temperature, the patient's general condition, her behavior under Koch's tuberculin test, and an examination of the other organs of the body. In still other cases it is necessary to make an exploratory puncture in order to ascertain the character of the fluid. If the fluid is an exudate, it will present the characteristics described above. The fluid of different ovarian cysts varies considerably in specific gravity, from 1.007 to 1.020 or more. In one case it is a thin serous fluid; in another, a gelatinous material. It contains considerable albumin and paralbumin. Microscopically there is nothing peculiar to these cysts except the cylindrical epithelium occasionally found.

Localized purulent exudates may present the same physical signs as an ovarian cyst, but the constitutional disturbances and blood changes are so marked, and the history of the onset shows such an acute beginning, that it is not often that any confusion arises between the two conditions. Exploratory puncture will remove the doubt, if any exists.

Echinococcus cysts developing in the peritoneum or tissues near the ovaries may in some respects resemble ovarian cysts. The discovery of the thrill peculiar to the former cysts, or the finding of the hooklets and scolices in the fluid evacuated by exploratory puncture, would naturally remove all doubt.

Hydronephrosis is at times confused with the ovarian cyst. It presents, however, this distinguishing feature: it lies behind and to the side of the colon and small intestines, while the ovarian cyst forces these upward and backward. The ovarian cysts rise out of the pelvis, while the hydronephrosis comes forward and downward from the lumbar region. Many cases of hydronephrosis present urinary changes, and in some cases the differentiation can be made certain by the demonstration, by palpation, of normal ovaries. Puncture of the hydronephrosis may yield a fluid containing urea.

Pancreatic cysts can almost always be distinguished by the fact that they displace the colon downward.

The recognition of pedunculated fibroids of the uterus, when the uterus is otherwise free from fibromata, is a very difficult matter, and in many cases the differentiation can be made by exploratory incision only.

Cystic fibromata of the uterus may very closely resemble ovarian cysts, but usually they are of slower growth and excite less constitutional disturbance.

Tumors of the liver and spleen can be differentiated by the signs described in the paragraphs devoted to these subjects. Tumors of the omentum, mesentery, and peritoneum are not always easily distinguished from ovarian cysts, but in most cases they can be shown to arise above instead of in the pelvis.

Ascites and cysts of the ovaries have quite often been

confused, but this error is possible only when the cyst is so large as completely to fill the abdomen or the ascites is so great that there is no central area of tympany. In other cases the error arises from carelessness. The history of an ovarian cyst is far longer than that of an ascites. If the fluid in the abdomen is a transudate, it is a symptom of some disease which ought to show other symptoms as well. Usually the primary disease is of the liver, but it is possible for either a heart or a renal disease to cause an ascites without producing any œdema of the legs. The various forms of chronic peritonitis may give rise to as large collections of fluid in the abdomen, but the history is usually brief, and the constitutional symptoms of tuberculosis or carcinoma, the two common causes of chronic peritonitis, are either present already or soon develop. Exploratory puncture is a valuable aid and should be employed.

Solid Tumors of the Ovaries.—There is a large variety of these tumors, none of which presents anything especially characteristic in its clinical course. The most important are the carcinomata, the sarcomata, and those tumors which result from tuberculosis. The carcinomata grow rapidly, producing irregular nodular tumors in the pelvis and lower part of the abdomen, and accompanied by the symptoms of a chronic peritonitis, by cachexia, and by anæmia. Carcinoma and sarcoma cannot be distinguished clinically. The differentiation of these from the tumors produced by tuberculous disease is often very difficult, especially when the patient is of such an age that either might be present. A positive reaction to the Koch tuberculin test speaks for tuberculosis, but the failure of such reaction does not exclude it. Leucocytosis speaks for cancer. Before a correct diagnosis can be made, it may be found necessary to resort to an exploratory operation.

There are still other pathological conditions in the pelvis which manifest themselves as abdominal tumors; such are, for example, a collection of fluid in a Fallopian tube, a pelvic abscess, and an extra-uterine pregnancy. The resulting abdominal tumor may be of considerable size. In such instances, however, the history of the case and the existing symptoms and evidences usually render the diagnosis plain.

Tumors of the Colon.

These tumors, irrespective of their nature, induce alterations in the character and frequency of the movements of the bowels.

Fecal Tumors.—These are very common, especially in women, and have been the source of many embarrassing errors, all of which could have been avoided if a thorough evacuation of the bowels had first been secured. The fact that the patient's bowels have moved daily should not lead to the neglect of this precautionary measure, for the fæces may accumulate in large masses even when the bowels move daily.

The fæces tend to accumulate in the flexures of the colon—the sigmoid, the splenic, and the hepatic flexures—and in the cæcum, but they may accumulate anywhere in the course of the large intestine. The resulting tumor may be of large size, and its outlines are usually of irregular shape. While it possesses a certain degree of solidity, it can generally be moulded into a different shape, and this new shape will remain permanently. These tumors may possess considerable motility. According to the different sites which they occupy they may simulate a great variety of pathological conditions, but in all such instances the simple evacuation of the bowels will quickly clear up the diagnosis.

Gas in the Colon.—This may cause a great distention of the abdomen, and this enlargement, at least at first, is limited to its outer and upper portions, the central portion being left free. The fact that the swelling is due to gas is shown at once by percussion. These accumulations of gas are often of great significance in cases of intestinal obstruction, giving as they do some clew to the site of the obstruction; it being evident that the lower the obstruction the greater will be the portion of the colon distended. The degree of distention depends mainly upon the amount of gas, but the resistance of the intestinal walls is also important, and when they are weak and have lost their tone—as, for example, in cases of generalized peritonitis—the distention is often extreme. Usually this distention of the colon with gas is accompanied by a like condition in the small intestines.

Cancer of the Colon.—The clinical picture includes pain, which is both localized and radiating, and which often occurs in the form of attacks of colic. In most cases there is constipation, which may gradually increase even to the point of complete obstruction; but in some cases there may be diarrhœa. The stools usually become small and ribbon-like, and are often mixed with mucus, blood, and pus, and sometimes contain fragments of the tumor tissue. These local symptoms are accompanied by the secondary anæmia and cachexia which are common to carcinoma, no matter what organ it may involve.

The presence of a tumor which can be felt is by all odds the most important symptom; and while it does not exist in all cases, it certainly does in the great majority of them. The size of the tumor varies, and may reach that of an adult head. It is hard, irregularly round or cylindrical in shape, and furnished with a smooth or nodular surface. As a rule it is moderately tender, but it may be extremely tender in certain cases.

The tumor is generally very movable, especially when it involves the sigmoid flexure or the transverse colon; but it may also be movable when it involves the cæcum or either of the longitudinal portions of the colon. Such tumors may be moved by the hand of the examiner, by the peristaltic movements of the intestines, by the force of gravity, and by the respiratory motions. The passive motility is most marked in the case of tumors of the sigmoid flexure and of the transverse colon, on account of the greater length of their mesocolon. The displacements due to the force of gravity are often considerable and may render the diagnosis quite difficult, for the reason that the tumor may be found occupying a position remote from the normal site of the colon. Thus, for example, a tumor of the transverse colon may lie at the pelvic inlet, or one of the sigmoid flexure may lie close to the cæcum.

The accumulation of the fæces above the point where the lumen is narrowed by the carcinoma leads to frequent errors in the matter of estimating the size of the new growth. These fecal masses may feel as hard, firm, and irregular as the cancer itself, and the palpating finger may not be able to distinguish the one from the other. In such cases, as in those in which it is necessary to distinguish between the fecal mass and other forms of tumor, vigorous and repeated purgation, and flushing of the colon, must be practised.

Peritoneal exudates, especially those about the appendix, may be extremely difficult to distinguish from carcinoma of the cæcum. They may form hard and irregular tumors, which may obstruct the intestinal canal and may cause bloody and purulent stools. The presence of fever and an œdematous condition of the skin, taken in connection with the history of the case, will point to peritonitis.

Tumors of the transverse colon, because of their close anatomical relations to the stomach, duodenum, and pancreas, may be confused with tumors of these organs. The symptoms of tumors of the colon are chiefly disturbances in defecation, such as constipation or diarrhœa; bloody, mucous, or purulent stools; and ribbon-like form of the latter. These tumors are also more movable than are, as a rule, the tumors of neighboring organs. Distention of the colon from below with gas or fluid can be followed upward to the tumor mass, where it is stopped or retarded. Inflation of the stomach throws the tumor downward and forward.

In cases in which the tumors have migrated from the normal location of the viscus, their relations to the colon can be demonstrated by inflation of the colon.

Tumors of the sigmoid flexure may be confused with

tumors arising from the ovaries, tubes, and peri-uterine tissues, but the symptoms of intestinal disturbances are more marked here than in the case of tumors situated higher up. A careful physical examination will reveal differences between these different conditions.

Tumors situated lower down, as in the rectum, are not abdominal tumors, but they have so important a bearing upon them that it should again be stated that in all cases which are in the least obscure, even when there are no symptoms pointing directly to the rectum, the latter should be examined.

Appendicular Abscesses.

These are often of large size. Disease of the appendix may cause an abscess to form not merely in the immediate vicinity of that organ, but also in some remote part of the abdomen. These more remotely situated abscesses have been considered in the paragraphs devoted to localized and encapsulated peritonitis, but it still remains to mention the abscesses in the region of the appendix. While it is true that the diagnosis of appendicitis previous to the formation of a tumor is often difficult, after this has happened the diagnosis is easy. The size, shape, and exact location of the tumor are subject to wide variations, but the history of a sudden onset and the existence of localized pain, associated with gastro-intestinal disturbances, with a chill, and with elevated temperature, suffice to show the nature of the process.

Abscesses in this region arising from other structures are encountered, but they are decidedly less common than the appendicular abscesses. Those which develop in the female genitalia are frequent, but the history shows disturbances in the functions of these organs and opportunities for their infection. These facts, taken in conjunction with the results of the pelvic examination, suffice for making the differential diagnosis. Sometimes gravitation abscesses due to disease of the spine are mistaken for appendicular abscesses, but this error may be avoided by examining the spine and by noting the absence of the usual history of appendicitis.

Tumors of the Abdominal Wall.

All forms of tumors may occur in this part of the body, but their relations to the abdominal walls are so manifest that they need no consideration here.

Robert B Preble.

ABENAKIS SPRINGS.—Location.—Near St. François du Lac, Quebec.

Post-Office.—Abenakis Springs, Quebec.

Hotel.—The Abenakis House.

Access.—From Montreal, by Richelieu and Ontario Navigation Co., by Grand Trunk and South Shore railways to Sorel, thence by boat to the springs. For the season of 1900 the South Shore Railway will be running direct to the springs.

Analysis (J. Baker Edwards).—Total saline solids, 110.3 grains to the pint. These are chiefly chlorides of sodium, magnesium, calcium, and potassium, with traces of lithium. The water also contains traces of bromides, iodides, and phosphates. It is very lightly carbonated.

A second spring is mildly sulphurated.

These springs are pleasantly situated on the west bank of the St. Francis River, near its confluence with the St. Lawrence, sixty miles east of Montreal. The surrounding country is elevated and dry and well settled. The hotel is new and well ventilated, possesses all modern conveniences, and is well managed. Hot and cold baths are supplied. *Beaumont Small.*

ABERYSTWITH.—A much-frequented seaside resort on the coast of Wales. The town of Aberystwith lies on the shore of Cardigan Bay; its population, in 1890, was 6,650; it possesses a fine beach; has excellent hotel accommodations; and, situated as it is in the midst of some of the most attractive scenery of Wales, the excursions into the surrounding country are very enjoyable. Concerning the climate of Aberystwith, the writer is unable to present accurate data for the place itself, but the subjoined table, copied from Hann's "Handbuch der Klimatologie," may serve to give some idea of its temperature during the colder months of the year. Llandudno lying some 75 miles north of Aberystwith, and Barnstaple lying about 125 miles to the south, both of which places have a similar exposure to that of Aberystwith, it is fair to assume that the temperature of the latter place differs but little from that of either of the above-mentioned towns, whose average temperature is given by Dr. Hann. It would therefore appear that the winter temperature of Aberystwith must be little colder than that of Ventnor in the Isle of Wight, the figures for which latter resort are also quoted from Hann's table for purposes of comparison.

Name of Place.	N. Lat.	Nov.	Dec.	Jan.	Feb.	Mar.
Llandudno	53° 21′	44.96°	42.44°	41.72°	42.44°	43.70°
Barnstaple	51° 5′	45.50°	42.62°	42.26°	43.34°	44.96°
Ventnor	50° 35′	46.22°	43.16°	41.72°	42.62°	44.24°
Aberystwith ...	52° 25′					

Huntington Richards.

ABIETIC ACID ($C_{44}H_{64}O_5$).—An organic acid, which, in its anhydrous state, chiefly composes common rosin. It also occurs in many other coniferous plants.—*H. H. R.*

ABORTION.—While most Continental writers apply the term abortion to all cases in which the product of conception is expelled from the uterus at any time preceding the period at which the fœtus becomes viable, that is to say, before the seventh calendar month of gestation in the human subject, many American and English writers make a distinction between abortion and miscarriage, restricting the former term to the expulsion of the ovum prior to the fifth month, and applying the latter to such expulsion between the fourth and the seventh months. This distinction, although more or less arbitrary, has some practical justification, inasmuch as abortion, thus defined, differs notably in several particulars from the process of parturition at term—a difference that becomes trifling in the case of miscarriage. It is well for the practitioner to use the word miscarriage when talking to patients, for women seem to have an aversion to the term abortion. Certain qualifying words are occasionally added, such as "ovular," "embryonal," and "fœtal," but they are of little real significance.

Causes.—These attach either to mechanical injuries to the ovum or its uterine attachment, to morbid conditions of the ovum, or to diseases of the maternal organism. Under the first head must be included not only direct traumatism, but also hemorrhages between the fœtal and the maternal layers of the placenta, whether due to violence, such as falls, blows, and the like, or to a diseased state in either the mother or the ovum; the latter, of course, falling also under one of the remaining heads. Strictly speaking, indeed, the immediate cause of almost every abortion is some abnormal state of the ovum resulting in the death of the embryo, but this in turn may be due to some defect in the maternal organism, or, for that matter, to disease in the father, as exemplified by the frequency with which abortion takes place as the result of syphilitic contamination of one or the other of the parents. Habitual abortion, it is well known, raises the presumption of syphilis. As regards pathological conditions of the ovum, it is generally to disease of the placenta, or a crippling of its respiratory and nutritive functions by effused blood, that the death of the embryo is to be traced, although cases are not wanting in which the circulation in the umbilical vessels has been so interfered with as to produce the same result.

In so far as the mother's system is at fault, much stress was laid by the older writers on the "habit of abortion." It was taught that when several successive pregnancies

in the same subject had ended in abortion, no matter what the cause, a habit was thereby established by virtue of which there was a tendency for subsequent pregnancies to end in the same way, and at about the same period, even if the original causes were no longer operative. There may be some truth in this doctrine, but it certainly has not now the hold upon medical opinion that it had formerly. The exanthematous fevers, it is well known, and particularly smallpox, are prone to give rise to abortion, either by infecting the embryo, or by the tendency to hemorrhages, uterine among the others, to which they give rise. Apart from these acute diseases, it is possible that various depraved conditions of health on the part of the mother may occasion abortion, but on this score our precise knowledge is meagre. There are certain medicinal substances that, when taken into the mother's system, may induce uterine contraction, and thus bring about the premature expulsion of the ovum, such as spurred grain (generally ergot of rye) and cotton-root. Excessive purgation also may lead to the same result. Surgical operations done on pregnant women have been supposed to involve grave risk of abortion, but evidence has been accumulating of late years to show that this danger has been much overrated. A striking example is seen in the frequency with which even so serious an operation as ovariotomy is performed during pregnancy without interrupting the process of gestation.

Various morbid conditions of the uterus and its surroundings, however, are justly credited with producing a tendency to abortion, but, with regard to one of them, it seems to me that more has been assumed than the facts warrant. I refer to laceration of the cervix, whereby a lack of retentive power is said to be set up. It cannot be denied that lacerations are often accompanied by conditions unfavorable to the due continuance of gestation, or that they tend to keep up such conditions, even if not directly chargeable with their production; but this is quite a different matter from admitting a loss of mechanical retentive power in the cervix as a cause of abortion, for it should be borne in mind that the ovum maintains its position in the uterus by the implantation of its chorionic villi in the uterine mucous membrane, and not in any sense by resting on a support beneath, as on a shelf.

Abortion induced for therapeutical purposes will be found treated of under the head of *Labor, Premature Induction of*.

Frequency.—Although abortion does not figure prominently in the statistical lists of public institutions, since it is only under unusual circumstances that women betake themselves to a hospital during the process, the general experience of family practitioners shows that its occurrence is common. Add to the cases they are called upon to treat those which are brought to their knowledge long after they have taken place, while questioning patients as to their past history, and allowing for those that are concealed, as well as for those as to which there is an honest feeling of doubt (since it is unquestionable that many abortions occur during the very early weeks of gestation, before the existence of that condition is suspected, and are mistaken for a mere unusually copious and painful menstruation), and we find ourselves obliged to admit that abortion is by no means of uncommon occurrence. As to the period of gestation at which it oftenest takes place, the experience of most writers is to the effect that it is on the completion of two and a half or three months of gestation, leaving out of account the very early abortions before alluded to, since they are involved in so much uncertainty that it is impracticable to estimate their frequency with any approach to precision.

Symptoms and Diagnosis.—Sometimes the ovum is cast off rapidly, with scarcely a symptom beyond a sharp onset of abdominal pain, and a few gushes of blood. In such cases, either the diagnosis is established very promptly, or else it is never made with certainty; but it never rests on symptoms. These cases, however, are exceptional. Usually a considerable period is occupied by certain symptoms pointing to a disturbance going on within the pelvis, notably, uterine hemorrhage and pains like those of labor. When these two phenomena are found to coexist in a marked degree in a woman supposed to be pregnant, the inference that an abortion is impending presents itself at once, and most commonly it will be justified by the event. But such is not always the case. Uterine hemorrhage, or at least hemorrhage from the cervix, is not very uncommon in pregnant women who go to full term, depending generally on antecedent uterine disease. Let one of these hemorrhages coincide with an attack of colic, or of lumbago even, and the symptoms that ordinarily usher in an abortion may be very closely counterfeited. It may even happen that what, in a certain sense, may be called a product of conception, may be expelled from the uterus, and yet no abortion takes place. Reference is here had to the decidua that is commonly cast off from the uterus in cases of extra-uterine pregnancy, a condition that is most frequently accompanied, too, by hemorrhage.

Still, with every allowance for these exceptional occurrences, the fact remains that paroxysmal uterine pain, accompanied by a flow of blood from the vagina, almost invariably, when met with in a pregnant woman, presages the premature expulsion of the ovum. This suspicion once aroused in the practitioner's mind, the first thing to be settled is the question of the existence of pregnancy. The diagnosis of pregnancy will be found treated of elsewhere in this work, and, therefore, it will not now be dwelt upon. Nor, for practical purposes, is it necessary to give much more consideration to the diagnosis of threatened abortion. The practical rule should be, in all cases in which the two symptoms, uterine pain and uterine hemorrhage, are marked in a pregnant woman, to treat her as if an abortion were impending. There are, indeed, certain cases of uterine disease that may simulate abortion very closely—notably cases of submucous uterine tumors so situated and so attached as to cause expulsive pains by the impediment they may offer to the escape of the flow of blood to which their presence gives rise. In such instances, however, we shall usually be able to get the history of past occurrences of the sort —a history to be contrasted with the sharp picture of suspended menstruation followed by a profuse and painful flow in a woman previously free from such troubles. A more difficult problem is presented in cases in which an abortion is really in process, but has been arrested in its course. Perhaps the simplest form of this condition is the so-called "cervical pregnancy" of certain German writers, in which the ovum is detached from its connection with the uterine wall, and is forced down into the cervical canal, where it is retained in consequence of a failure of the os externum to dilate, or simply by reason of a suspension of the uterine contractions. These cases commonly offer no special diagnostic difficulty, and, the retention being but transitory, any doubt is speedily cleared up. A more common irregularity is the rupture of the fœtal membranes and the escape of the fœtus, either unperceived or unacknowledged, before medical aid is summoned, the placenta still being retained. Under such circumstances, it happens not infrequently that the patient resumes her ordinary course of life, seeking treatment, if at all, only on account of a uterine discharge, which may not even be bloody. In such instances the uterus will be found enlarged and especially elongated, freely movable, free from tenderness, and with nothing to account for its enlargement and its peculiar shape save the supposition of an incomplete abortion, and usually the question can speedily be settled by giving ergot—a practice quite safe under such circumstances. It is scarcely necessary to add that, in all cases of suspected abortion, everything expelled from the vagina should be saved for examination. In the absence of the embryo, the recognition of chorionic villi will be decisive. These will often be found on the inner side of the bag-like structure expelled, the membranes having been turned inside out in the process of expulsion. In very early abortions the ovum is usually cast off entire.

Prognosis and Sequelæ.—If we disregard the fœtus, which is necessarily sacrificed, the prognosis for the

mother is always a matter of some doubt, but generally, provided the case is well managed, favorable. The immediate danger is from hemorrhage, which ceases on the complete evacuation of the uterus; next, and much more to be feared, is the risk of septic fever from the absorption of decomposing portions of the ovum retained in the uterus; these perils passed, inflammatory complications, subinvolution, and the like are still to be feared. But very few women die from the direct effects of hemorrhage occasioned by abortion, but many are exsanguinated to a degree that materially deteriorates their health; more often they succumb to septic absorption. The acute inflammatory sequelæ may be either peritonitis, cellulitis, oöphoritis, or any one of the various forms of metritis. Aside from the part played by mild septic contamination, these affections are largely dependent on the cause of the abortion, being uncommon in cases not occasioned by instrumental interference. On the whole, it may be said that the great majority of women escape a fatal result. At the same time, abortion is one of the most fertile causes of chronic pelvic disease; usually, however, these consequences may be avoided by careful treatment.

Treatment.—This resolves itself into the prevention of abortion, the management of the process, and the after-treatment. If we admit the "habit" of abortion, we must usually look for its solution in some degeneration of the placenta, whereby it becomes unfitted to carry on the processes of respiration and nutrition for the embryo. This occurrence may be due to syphilis; in that case mercurial treatment affords the main chance of success; the corrosive chloride of mercury in doses of from one-thirty-second to one-twenty-fourth of a grain, three times a day, will commonly be found to afford all the advantage that is to be gained in this direction. In the absence of syphilitic infection, some obstetricians believe that an error of hæmatosis is often at the bottom of repeated abortions, and on this theory the administration of potassium chlorate has been recommended. I am not aware, either that the theory is well founded or that the remedy is of any value; still, with proper precaution, there can be no objection to its use—that precaution being to guard against the injurious effects of the drug upon the kidneys; and, therefore, to avoid large doses, and to abstain from them particularly in cases in which the pregnancy is somewhat advanced, since the latter months of gestation are apt to be fraught with more or less interference with the renal function. As for the use of so-called uterine sedatives, it is not to be thought of until the process of abortion is actually threatened. Of course, such patients as are now referred to should be instructed to refrain from all the excesses and irregularities that have been mentioned as among the exciting causes of abortion.

Suppose, however, that symptoms are present showing that an abortion is imminent. In many instances the process may be prevented, and the expectation of success should not be abandoned until there is physical evidence that the expulsion of the ovum is going on. No amount of hemorrhage and no amount of pain, within ordinary bounds, should be taken in themselves as rendering attempts at prevention absolutely hopeless. Perfect rest is to be enjoined, but the low diet and cooling drinks of bygone times are not to be depended upon in the slightest; the moderate use of opium and the application of heat to the spinal column, at the junction of the dorsal with the lumbar portions, are the most trustworthy measures. Theoretically, we may admit that ergot may sometimes be useful, by checking a hemorrhage that might detach the placenta, but, practically, there is such danger of its inducing uterine contraction that it must be regarded as at best but a doubtful remedy. The use of viburnum prunifolium has of late years been recommended as a uterine sedative, and there is respectable testimony in its behalf. It should be given in doses of half a teaspoonful of the fluid extract every three hours. To mitigate its disgusting taste, it may be combined with an equal amount of tincture of cinnamon.

When it has once become evident that abortion must take place, the safe conduct of the case calls for close supervision; but, even then, discretion is usually more to be advised than activity. Ordinarily, manual interference is quite unnecessary, beyond what may be needed to keep the physician informed of the progress made, and to check hemorrhage. The utmost pains should be taken to maintain the integrity of the ovum as long as possible, for when it is expelled entire there is commonly an end to all anxiety. Herein, in great measure, lies the safety of accidental abortions as compared with those induced by criminal practices, in which the fœtal envelopes are almost always punctured, with the result of allowing the embryo to be cast off early in the process of abortion, while the secundines remain behind, a shapeless mass, upon which the uterus has to act at a great mechanical disadvantage. So long as rupture of the membranes can be prevented, our interference should be limited to controlling pain and hemorrhage; an aseptic vaginal tampon, properly introduced, may always be relied upon to fulfil the latter indication. It should be inserted leisurely and methodically, with the aid of a Sims speculum, and generally it should be removed at the end of twelve hours, when a fresh one may be applied, if necessary, after treating the vagina with an antiseptic douche. To allay excessive pain, there is nothing equal to opium, but it should not be pushed to narcotism or to such an extent as to abolish uterine action; ergot may properly be given if the hemorrhage is excessive and accompanied by inertia, but the more its use is avoided, the better will be the results on the whole. It is better to rely on the tampon, and that of itself stimulates uterine contraction.

If, unfortunately, the sac of the ovum has been emptied of its contents, and the secundines are retained, the question of their removal will come up. There are extremists who are given to energetic interference in all such cases. On the other hand, the timorous trust too long to nature. In such a case, as in most others, the middle course is followed by the judicious. The best practice seems to be not to resort to forcible removal of the remnants of the ovum unless there are particular reasons for doing so. These reasons are for the most part: (1) Signs of septic changes; (2) the undue continuance of hemorrhage. Under either of these circumstances there should be no hesitation; but the operation should be done without instruments, if possible. In some cases, however, a wire curette is necessary. The patient should be anæsthetized, and, as she lies across the bed, on her back, with the hips brought well to the edge of the bed, the operator, who has previously rendered his hands and the parts about the patient's pudenda thoroughly aseptic, should pass one or more of his fingers as far as may be necessary into the uterine cavity and tease away the retained portions of the ovum. The work will be decidedly facilitated if the uterus is gently but firmly depressed by an assistant, who should make pressure on it through the abdominal wall. As a preliminary step, dilatation of the cervix may be necessary, but, as a rule, this should not be accomplished with tents, whether of sponge or of any other material that expands on imbibing moisture. If the fingers will not answer, graduated metallic or hard-rubber dilators should be employed, and, when they are used, the operator should himself make the counter-pressure on the fundus. After the operation is finished, the uterus should be washed out with an antiseptic solution, perferably a straw-colored mixture of tincture of iodine and water, injected through a double cannula.

The after-treatment in cases of abortion hinges chiefly upon enforcing rest for a length of time equal to that usually adopted after labor at term. The special indications do not differ from those met with after ordinary parturition, except that the breasts are not apt to give trouble.

Missed Abortion.—This term was applied by the late Prof. J. Matthews Duncan, of Edinburgh, to the long-continued retention of the dead ovum in the uterus, where it becomes macerated or mummified, and whence it is finally expelled. *Frank P. Foster.*

ABORTION, CRIMINAL.—In most, perhaps all, of the United States will be found statutes making it a crime to produce, or to attempt to produce, an abortion or miscarriage of a woman by artificial means. In a few this applies only to attempts in the cases of women actually pregnant; but inasmuch as crime consists of a combination of a forbidden act and a wilful and unlawful intent, it is both reasonable and just that an attempt to produce an abortion should be prohibited even when the woman is not actually pregnant, although she and the perpetrator think she is. In many of the statutes will be found saving clauses freeing from criminal liability the person who produces a miscarriage by artificial means, under circumstances from which it must appear that the fœtus is dead or that it is necessary to save the mother. It is suggested as a precautionary measure to any medical practitioner who contemplates arresting gestation, in order to avoid suspicion, to consult some other member of the profession of unquestioned standing, and to obtain the consent or approbation of some one or more of the relatives of the woman.

The statute of Pennsylvania is a good example of the best of those passed in this country. It is as follows:

1. "If any person shall unlawfully administer to any woman, pregnant or quick with child, or supposed and believed to be pregnant or quick with child, any drug, poison, or any substance whatsoever, or shall unlawfully use any instrument or other means whatsoever, with the intent to procure the miscarriage of such woman, and such woman, or any child with which she may be quick, shall die in consequence of either of said unlawful acts, the person so offending shall be guilty of felony, and shall be sentenced to pay a fine, not exceeding five hundred dollars, and to undergo an imprisonment by separate or solitary confinement at labor, not exceeding seven years."

2. "If any person, with intent to procure the miscarriage of a woman, shall unlawfully administer to her any poison, drug, or substance whatsoever, or shall unlawfully use any instrument or other means whatsoever, with the like intent, such person shall be guilty of felony, and being thereof convicted, shall be sentenced to pay a fine, not exceeding five hundred dollars, and undergo an imprisonment by separate or solitary confinement at labor, not exceeding three years."

As a practical matter, it is but rarely that the prosecuting power has the opportunity of invoking this law against a violator of it, for the reason that in all cases of criminal abortion the operation is performed, or the drug is administered, at the request, or it may be the earnest solicitation, of the woman herself, who for this reason is as cautious to avoid detection as is the perpetrator of the crime. It will be found that almost all of the cases of criminal abortion which have proceeded as far as indictment and trial, are those in which the patient has died from the effects of the operation or the administration of the drug. Even in these cases it has been a rare experience to obtain a conviction because of the secrecy with which this crime is committed, resulting usually in the absence of evidence of those facts which can be used against the culprit. Persons who commit offences deliberately always avoid or destroy those circumstances which are incriminating, so far as is possible.

Irrespective of the above-mentioned statutes, both in England and in this country one who administers to a pregnant woman a drug, or employs upon her an instrument for the purpose of procuring a miscarriage, in consequence of which she dies, or the child dies after birth, by reason of being prematurely delivered, is guilty of murder. The culprit will be indicted for murder or manslaughter, first because any inferior grade of crime of which he may be guilty will be merged in the felonious homicide, which in the eyes of the law is considered the gravest of all offences; and secondly, it may be that a dying deposition has been obtained from the patient.

It has been held that if there be no intent to kill, or to inflict grievous bodily harm, and the means employed be not dangerous, although used for an unlawful purpose, the crime, when death ensues, may be manslaughter, which is an inferior grade of homicide; otherwise the crime will be murder, and may render the accused, if convicted, liable to the death penalty. It is suggested, however, that any known means, when used for this purpose, will be dangerous and should be so considered. This question is really dependent upon the judgment of the criminal prosecutor, for it is always competent for him, unless he is restricted by some statutory provision, to elect to have the prisoner indicted for the inferior grade of the offence, and abandon, on behalf of the state, the superior grade.

When a reputable physician takes charge of a patient upon whom he discovers an abortion has been performed, and who subsequently dies, he is bound by law to certify the cause of death to the Health Department. In this it may be necessary for him to disclose the fact of the perpetration of a crime; but is it his duty to inform the police authorities as soon as he has discovered the crime? This is an ethical question which need not be discussed here—it is a proposition which each physician should consider for himself. Auxiliary to it is this question: Should he, when the opportunity arises, obtain from the patient a statement which could be used as a dying deposition in a criminal prosecution against the abortionist?

Dying Depositions.—For the benefit of the physician who is willing to aid the State in detecting the perpetrator of this nefarious crime, it may be stated that if the patient dies and the perpetrator of the abortion is charged with either murder or manslaughter, it will be admissible to offer in evidence the dying declaration of the patient, if she made one. Statements made under such circumstances are entitled to great weight. It has been wisely said by an eminent English jurist, Lord Chief Baron Eyre, "that such declarations are made in extremity, when the party is at the point of death, and when every hope of this world is gone; when every motive to falsehood is silenced, and the mind is induced by the most powerful considerations to speak the truth; a situation so solemn and so awful is considered by the law as creating an obligation equal to that which is imposed by a positive oath in a court of justice." Such declarations are admissible in evidence only in those cases in which the indictment charges the culprit with the murder or manslaughter of the deceased, and not in those in which the gravamen of the charge is a violation of one of the above-mentioned abortion statutes. The declaration should also be confined to a statement of the circumstances of the death, *i.e.*, the person who performed the operation, the method, time, and place of performance, and such other facts as are germane to these.

To render such a declaration admissible in evidence, it is requisite that the declarant should be in actual danger of death at the time it is made, that she should fully realize her impending danger, and that death should actually ensue. It is not necessary that the declarant should state that she realizes that her speedy demise is impending; it is sufficient if it satisfactorily appears from any other circumstances, such as taking leave of her relatives, or receiving extreme unction and the like. If, however, she has any hope of recovery, no matter how slight, such testimony will be inadmissible, though death might speedily ensue. Such a declaration was rejected where the dying person stated: "I have no hope of recovery, unless it be the will of God"; it being held by the court that such statement indicated that all hope had not been abandoned. It need not be under oath, as the solemnity of the occasion is held to be equivalent to the sanctity of an oath. It may be taken orally, but if reduced to writing, it should be carefully preserved and produced at the proper time. It should be confined to a statement of facts, not theories or opinions.

Criminality of the Act.—So far as the culpability of the act is concerned, it is immaterial whether or not quickening has occurred, and whether or not the fœtus *in utero* is dead, unless there is a saving clause in the abortion statute as above stated. The criminality is just as great on the day of conception as at any other period of

gestation. Nor is it a defence or excuse to the criminal charge that the mother consented to, or solicited the performance of, the abortion. It has been decided by some courts that a woman who consents to the performance of an abortion is an accomplice, by others that she is not, but this is a purely legal question. The rule of law generally adhered to is, that where a witness is held to be an accomplice there should be some corroboration of her testimony in order to justify a conviction of the accused.

Questions in Cases of Fœticide.—In every case of fœticide the important questions for consideration are:

1. Has the fœtus *in utero* been destroyed?
2. Has this been produced by natural or artificial causes?
3. If by artificial means, was the act justifiable or criminal?

In considering the first question an examination should be made of the clots and other substances expelled from the genital organs, for the purpose of ascertaining if they contain any of the products of conception. If the fœtus be found it will be necessary to determine, if possible, if it was born alive; if so, its probable age and the cause of its death. A careful scrutiny of it may disclose punctures, wounds, or injuries which indicate the unlawful use of an instrument.

If the fœtus is not found the expelled substances should be examined under water, as an ovum, if one is present, is more easily discovered in this way. Nor ought the investigator trust to the naked eye, as much may be lost without the use of a microscope. When the criminal operation is performed in the early stages of pregnancy, the ovum is frequently expelled intact; after the formation of the placenta, the extrusion of the ovum usually precedes that of the placenta, the time intervening being variable, ranging from hours to weeks or months.

Did the abortion result from natural or artificial causes?—Both criminal and spontaneous abortion occur generally about the end of the third month. The symptoms discovered will vary with the period of gestation and the time, since the performance of the operation, at which the examination is made. When the operation is performed in the early stages of gestation, the appearances are not different from those in cases of tumors and some other troubles. The nearer the period is to full term, the greater will be the laceration of the uterus and vagina.

If death has resulted, a post-mortem examination will usually determine this question with certainty. An examination of the woman while living will probably be uncertain in its results, unless the evidence of instrumental interference is palpable or the woman is frank in her statement of the case. Finally, when drugs are used as abortifacients even the post-mortem may baffle the investigator. The most popular means of attempting criminal abortion is by aid of some instrument, for the reason that unless there is a strong predisposition on the part of the woman to abort, the result can rarely be accomplished by means of drugs. Among the many means in use for this purpose, according to reported cases, are: repeated and copious blood-lettings, drastic emetics and purgatives, ergot, cotton-root, savin, tansy, pennyroyal, rue. While any of these means, in a woman disposed to miscarry, may produce the desired result, in most instances it will be uncertain. The most effective drug for this purpose, according to cases reported, is ergot. Another method sometimes successful is the dilatation of the os uteri by means of a sponge tent. The introduction of some instrument into the uterus so as to rupture the membranes is the only certain method of producing contraction of the uterus and thus causing the extrusion of its contents.

In every case these methods of treatment will be accompanied with danger to the mother, and not infrequently they result in the mother's death without effecting a discharge of the fœtus.

The production of abortion being both immoral and criminal, except where the exigencies of the case require it as before mentioned, the practice in prohibited cases is confined to medical men of low professional standing, midwives, and other unskilful persons. It is this, no doubt, which makes the operation unusually dangerous. Were this branch of practice reputable, when conducted by a competent physician, according to the principles of modern surgery, it would result fatally in a much smaller number of cases. Just what percentage of these cases result fatally it is difficult to ascertain because of the clandestine method of treating them.

It has been noticed, even in cases of natural abortion, that as the process of gestation approaches its full term the muscles of the uterus grow stronger and are able to fulfil their function by contracting not only upon the contents of the womb before delivery, but also upon the bleeding vessels afterward. In cases of abortion in early stages of pregnancy there is greater danger of hemorrhage and of septic diseases such as pyæmia and puerperal peritonitis, because these muscles respond slowly and thus leave the uterine canal open to the introduction of germs and other foreign matter.

When consulted in a suspicious case, the physician should examine the vagina and uterus for marks of injury, wounds, perforations. He should notice if there are indications of irritants in the stomach and intestines, or inflammation in the bladder or kidneys resulting from the use of emmenagogues. He should note what drugs or instruments are in her possession and if there are any marks of violence upon her body, for abortion is sometimes attempted by the woman herself by this means.

Witthaus and Becker, in their work on medical jurisprudence, quote from Tidy's work on the same subject the following table suggesting a line of inquiry for the medical practitioner in cases of suspected criminal abortion:

I. *Examination of the Mother, if Living.*

1. Temperature.
2. As to the woman's predisposition to abort and the period at which abortion has commonly occurred.
3. General state of health. (Note existence of leucorrhœa, excessive menstruation, syphilis, asthma, malignant diseases, uterine diseases, etc.)
4. Whether the woman be well or ill formed. (Note pelvic malformations, effects of tight lacing, etc.)
5. Whether or not there be signs of recent delivery or of the expulsion of the uterine contents.
6. Whether any cause can be assigned to account for the abortion (*e.g.*, violent coughing, blood-letting, straining at stool, violent exercise, undue excitement, septic poisoning, violence, administration of medicines, etc.).
7. All injuries of the genital organs (consider whether the injuries might be self-inflicted.)

II. *Examination of the Body of the Mother, if Dead.*

Note—

(*a*) The necessity for care not to mistake the effects of menstruation for those produced by abortion.

(*b*) To avoid injuring the parts by the knife or otherwise during the autopsy.

(*c*) To consider the possibility of injuries being self-inflicted.

1. Note the existence of marks of violence on the abdomen or other parts.
2. The condition of the genital organs, noting all inflammations, rents, tears, perforations, etc. (if the uterus be injured it should be preserved).

Note also—

(*a*) The condition of the passage (relaxed or otherwise).

(*b*) The condition of the os uteri (virginal or gaping, etc.).

(*c*) Vaginal secretions, and if present their character.

(*d*) The general appearance of the breasts, presence of milk, etc.

3. Whether there be any signs of irritant poisoning in rectum, etc. (contents of stomach to be preserved, if necessary).
4. Whether the viscera generally indicate loss of blood during life.

III. *Examination of the Product of Conception.*
1. Nature of the supposed product of conception.
2. Consider whether there is evidence of a diseased condition of the membranes or placenta, *e.g.*, structural degeneration.
3. If a fœtus be found, determine (*a*) whether it was born alive; (*b*) its probable age; and (*c*) the cause of its death.
4. Determine whether, if there be wounds or other injuries, they were inflicted during life or after death.
IV. *Examination of All Drugs, Instruments, etc.*

Henry Duffy.

ABROMA. See *Sterculiaceæ*.

ABSCESS.—(Latin, *abscessus*, from the verb *abscedo*, I depart; *abscedo* and *abscessus*, used by Celsus in the sense of the gathering of the corrupted fluids of the body into an abscess. Greek, ἀπόστημα. French, *abcès*. German, *Eiterbeule*, though the Germans more commonly use the word *abscess*.) By the term abscess is meant a collection of pus within the body, the result of liquefied inflammatory products. This may occur in one of the preformed spaces, or in a newly formed cavity in solid parts. Certain adjective prefixes are used to denote duration, character, and situation of abscesses. Thus, as regards duration, they may be acute, subacute, or chronic. As regards character, the various terms used will be mentioned later. As regards situation, some of the following are the most frequent designations: alveolar (abscess in alveolus of tooth), axillary, bursal, cerebral, hepatic, ischio-rectal, mammary, mastoid, ovarian, pelvic, perinephritic, perityphlitic, prostatic, pulmonary, retromammary, retropharyngeal, splenic, sub-diaphragmatic, etc. Abscesses more or less free in pre-existing cavities usually bear special names: a collection of pus in the pleural cavity is generally designated as empyema, and this term is also applied to collections of pus in the gall bladder, the frontal sinuses, and other accessory nasal cavities (empyema of the gall bladder, etc.). Pyosalpinx means pus in the Fallopian tube; pyonephrosis, accumulation of pus in the pelvis of the kidney; hypopyon, pus in the anterior chamber of the eye. In other serous cavities one speaks simply of a purulent or suppurative pericarditis, peritonitis, ependymitis, meningitis, synovitis, or arthritis, etc., as the case may be. Pelvic abscess means a collection of pus in the pelvis, due to a circumscribed peritonitis, the remainder of the peritoneal cavity being shut off by adhesions. Whitlows, felons, boils, carbuncles, and furuncles are names of special varieties of suppurative inflammation which greatly resemble abscesses, and information concerning them will be found under the appropriate heads.

Causes of Abscess.—Abscesses are the result of a kind of inflammation known as suppurative or purulent. Clinically, this form of inflammation is almost without exception the result of infection with micro-organisms of various kinds. Experimentally, it is quite possible to produce suppuration by the introduction of various chemical and other substances, which directly or indirectly exercise positive chemotaxis upon the hæmal and other mobile or mobilizable cells of the body. Councilman, Uskoff, Grawitz, Orthmann, and others have by their experiments shown that this so-called chemical suppuration does take place; mercury, croton oil, turpentine, nitrate of silver, chloride of zinc, etc., are some of the substances used in the experiments, in which the action of bacteria, introduced accidentally or latent in the tissues, has been carefully excluded. Wyssokowitch and then Buchner studied the effects of the injection of dead cultures of divers organisms; Buchner experimented with the bacterio-proteins of numerous species of bacteria, and showed to general satisfaction that pus may be produced by proteid substances in the bodies of the bacteria. Animal and vegetable proteins also have pyogenetic properties. Bacterial toxalbumins are not pyogenetic.

In most cases abscess is the result of the presence in the tissues of some one or more of the common pyogenetic bacteria, first discovered by Ogston in 1881, subsequently isolated by Rosenbach in 1884, and completely described by Passet in 1885, namely, Staphylococcus pyogenes aureus, albus, and citreus, and Streptococcus pyogenes. Janowski tabulates 827 cases of abscess and suppuration in the subcutaneous tissue (the most frequent seat of suppuration), and in 605 the staphylococci occurred alone, in 154 the streptococcus, and in 68 staphylococci and streptococci were associated. These organisms have also been found to produce pus in man under experimental conditions. But abscess frequently follows the invasion of the tissues by organisms that are not constantly or generally pyogenetic; the number of organisms that are facultatively pyogenetic is quite considerable. Micrococcus lanceolatus (diplococcus of pneumonia), which is the most frequent pus-producer after the common pus cocci, may cause abscesses in the soft parts, suppurative otitis media, suppurative osteomyelitis, synovitis, peritonitis, etc. Bacillus mucosus capsulatus (pneumobacillus of Friedländer and B. lactis aerogenes) has been repeatedly isolated from cases of suppuration in the tympanic cavity, the antrum, and other accessory nasal cavities. Bacillus coli communis is frequently found in suppurative cholangitis, abscess of the liver, peritonitis, etc., and is pyogenic in animals. Bacillus typhi abdominalis, which has the power of remaining latent in the tissues, especially the bone marrow and the gall bladder, long after the primary attack of typhoid fever, is now and again found as the probable cause of abscesses in bones (typhoid osteomyelitis), suppurative cholecystitis, empyema, abscesses of the soft parts, etc. The typhoid bacillus produces pus in animals. Bacillus influenzæ may also induce purulent inflammation.

Among other bacteria capable of producing pus may be mentioned Proteus Zenkeri, bacillus of swine plague, bacillus of chicken cholera, Micrococcus tetragenus, Micrococcus intracellularis, Bacillus pyocyaneus, Bacillus prodigiosus, etc.

Bacillus pyocyaneus, the organism of blue pus, is not merely a chromogenic saprophyte; for it has been isolated as the only cause of otitis media, suppurative pericarditis, hepatic and ovarian abscesses, ascending urinary suppurations, etc. In two hundred cases of suppuration, Janowski found this bacillus only twice.

Staphylococcus epidermidis albus Welch is the most common organism on the surface of the body, being often situated deeper than can be reached by any of the present methods of cutaneous disinfection; it is closely related to Staphylococcus pyogenes albus, being according to Welch an attenuated form of this organism, and is probably the most general cause of "stitch-abscess."

The action of Micrococcus gonorrhœæ in a few cases has seemed to be distinctively pyogenetic.

Micrococcus pyogenes tenuis, which is usually mentioned as a pus coccus, has been isolated only nine times; in six instances it was found alone, in three associated with other organisms. The identity of this microbe is not fully established, and the question has been raised as to the probability that Micrococcus lanceolatus is an organism mistaken for it.

Bacillus pyogenes fœtidus is a rare pus-producing organism the relation of which to the colon group has not been settled.

In addition to being caused by bacteria, abscesses may be produced by divers fungi, such as the ray fungi (see *Actinomycosis*), in which case the pus may contain characteristic fungous clusters or granules; Oidium albicans and various forms of Blastomycetes are also pus-producers; Trichophyton tonsurans may cause cutaneous and subcutaneous abscesses (Sabouraud). Recently certain peculiar, refractory, subcutaneous abscesses have been shown to depend upon the presence of a fungus possibly belonging to the sporotricha (Schenck).

A form of abscess which is observed in hot climates and occasionally in other regions, and which occurs in the liver, has received the name of tropical or amœbic abscess of the

liver; it is caused by the transfer of organisms from the large intestine to the liver, through the portal vein, in amœbic dysentery. This would seem, therefore, to be an example of suppuration with abscess formation due to an animal organism, the amœba coli, but the exact relation of this parasite to the abscess has not yet been established: it may be that other microbes play an essential part, the presence of the amœba being largely secondary or accidental.

A number of cocci has been found to be pyogenetic only in animals, such as cattle, horses, etc.

The pyogenetic qualities of most of the organisms that have been mentioned have been satisfactorily established by experiments. It appears that of the warm-blooded animals, man is the most disposed to suppuration. Among the various conditions that especially favor suppuration may be mentioned the infectious diseases, both acute and chronic; conditions characterized in general by a lowering of the vital strength; diabetes mellitus, etc. The common pus microbes are normally present on the skin, in the oral cavity, and in the vaginal secretion. Local infections are likely to occur when the protective covering is injured in any way and the general strength reduced. The disposition to pyogenic infection created by the infectious diseases such as typhoid fever, gonorrhœa, influenza, scarlatina, variola, diphtheria, measles, dysentery, etc., is clearly shown by the frequency with which secondary mixed infections with pus microbes occur in these diseases. Secondary infection usually means the lodgment and pathogenic action of bacteria in the tissues and the blood of persons rendered especially susceptible by the influences of pre-existing infections with other microbes. The resulting abscesses may contain the microbe of the primary disease and of the secondary infection, or the latter only may be present. The phrase secondary infection is generally used in this sense. Abscesses may be the result of a primary polyinfection; thus staphylococci and streptococci not infrequently are associated in the same abscess.

When an abscess becomes old or chronic the microbes present are usually reduced in virulence, but by several passages through susceptible animals the virulence may be again greatly increased.

Origin of Pus.—Pus is the result of inflammation in which the exudate and the dead cells and detritus are liquefied by the action of digestive ferments produced either by the bacteria themselves or by the cells. The ferments either hinder the coagulation of the exuded serum or redissolve the fibrin once formed. The various factors in inflammation are therefore in full operation in the early stages of abscess formation, and the classical symptoms of acute inflammation—rubor, calor, dolor, tumor, functio læsa—are rarely seen to better advantage than in the beginning of an acute abscess in the skin or subcutaneous tissue. As a result of the action of the microbes present or of their products, and of divers chemical substances, the tissue cells in the immediate vicinity are injured, and this is followed by the well-known vascular changes of acute inflammation, leading to exudation of serum and leucocytic emigration. In response to the positively chemotactic substances, produced either by the bacteria directly (Leber), or by the action of broken-up necrotic fragments of cells destroyed by the bacteria, or by other causes (Buchner), the mobile cells of the blood and of the tissues accumulate in the inflammatory focus. Many of these cells become phagocytes, and intracellular and extracellular bactericidal and digestive ferments are produced. As a result of the disturbed intercellular equilibrium the fixed tissue cells begin to multiply and karyokinetic figures are seen at the borders of the area; the migratory cells also multiply. Thus is produced a mass which at first is denser than the normal tissue. Under the influence of the toxic substances necrosis of cells takes place, and, as already emphasized, the proteolytic ferments hinder coagulation of the inflammatory serum and dissolve the dead cells and shreds of tissue, and in this way pus is formed. The proteolytic action of ferments of bacterial origin is well illustrated by Rosenbach, who showed that under anaerobic conditions Staphylococcus pyogenes aureus dissolves white of egg and meat.

Pus is therefore an albuminous, non-coagulable fluid, rich in cells; it is distinguished from blood serum and lymph by not being spontaneously coagulable. Inflammation of a tissue associated with cellular infiltration but without recognizable solution of tissue—histolysis—does not give rise to pus.

Physical, Chemical, and Morphological Characteristics of Pus.—Typical human pus—the pus bonum et laudabile of the old writers—is a creamy, more or less mucoid fluid, usually of alkaline but not rarely of acid reaction, possessing a peculiar sweetish odor and a specific gravity of 1.030–33. Atypical, "thin" pus ("ichor") may have a much lower specific gravity, and such pus, mixed with fibrinous flocculi and shreds, and smelling of butyric acid, is regarded as the result of a virulent infection, and as indicating a cautious prognosis. Allowed to stand, pus generally separates into two layers, the upper being a transparent, yellowish fluid—"liquor puris"—and the lower, an opaque mass composed of the solid constituents of the pus. The liquor puris is much like blood serum and lymph in its composition, being somewhat less albuminous and not containing any fibrinogen; it contains considerable globulin, albumoses, and various extractives, such as leucin and tyrosin, more or less mucus, fats, and cholesterin, the latter especially in the case of old pus; among the mineral constituents may be mentioned sodium chloride and the phosphates of magnesium and calcium; finally, the serum of pus will be found to contain digestive, bactericidal, and other ferments and toxic substances, partly of bacterial, partly of cellular origin, the amount and the kind varying according as the microbe at work, its virulence, and the age of the pus vary. The odor and the color of pus are also subject to variation, depending on the cause and the situation of the abscess and the presence of secondary putrefactive bacteria. Pus associated with disease of the middle ear and of the brain is frequently fetid, due to changes of a putrefactive nature. In such cases lactic, valerianic, butyric, and other acids, H_2S, etc., are formed. Purulent accumulations in the vicinity of, or in connection with, the intestines generally acquire a fecal odor, which sometimes is intense. Pus may be mixed with blood so that its color on that account varies from bright red to brown or chocolate. Green or blue pus is the result of suppuration caused by Bacillus pyocyaneus, which produces a green pigment, pyocyanin. Abscesses caused by, or contaminated with, gasogenic organisms, such as the colon bacillus, Proteus vulgaris, and Bacillus aerogenes capsulatus, may contain a more or less frothy pus.

In addition to pus, abscesses may contain other substances, as blood, shreds of tissue, foreign bodies, parasites, cheesy and calcareous masses. When pre-existing cysts, such as retention cysts and follicular cysts, become the seat of purulent infection, the resulting pus is mixed with the cystic contents.

The formed elements present in pus are migrated leucocytes and wandering cells. Stricker insisted that the pus corpuscles were modified embryonal-tissue cells, and it stands to reason that some of the cells in pus may be of this origin; but it is now agreed that leucocytes form the great majority of the cells in pus. In acute abscesses the greater number of the cells are leucocytes of the finely granular, polymorphonuclear type; coarsely granular, eosinophiles and hyaline cells of different kinds with circular and oval nuclei are also found, and to what extent this cell comes from the blood and to what extent from the tissues is unsettled. There is great diversity in the appearances of the cells present in pus; the great irregularity in the shape of the nucleus is explained as due in some cases to its being fixed while the cell is in motion, in other cases to beginning degeneration and disintegration into the nuclear fragments commonly present. Among the disintegrating cells will be found those which still retain their amœboid movement. The protoplasm of many leucocytes often shows extensive fatty and

granular changes. In chronic abscesses the mononuclear cells are relatively more numerous. Janowski observed that the cells in pus are of the same general morphology in bacterial and in purely chemical abscesses. In the case of most abscesses, especially the acute, pus will contain, in addition to cells and cellular detritus, the special pus producing organisms, whose presence is usually readily established by the ordinary histological and bacteriological methods. In some cases, as for instance in abscesses caused by ray fungi, the organisms form peculiar grayish or yellowish granules which can be seen with the naked eye.

In domestic animals pus presents a variable macroscopic appearance. In horses, cattle, and swine it corresponds in the main with human pus; in dogs it is generally thinner and more serous; in rabbits, guinea pigs, and birds it is much thicker, almost caseous in appearance (Johne).

Cold Abscess.—Puruloid fluids are produced by softening of caseous foci and by the so called bland or aseptic liquefaction of thrombi. In these cases the process is not exactly the same as in ordinary suppuration, although fluids may result that greatly resemble pus.

The chronic, so called "cold abscesses" are in reality collections of softened tuberculous material. They are observed most frequently in connection with tuberculous arthritis and osteomyelitis. The contents of the cavities are formed slowly, and extension often occurs according to the laws of gravity. Thus "cold abscesses" associated with tuberculosis of vertebræ often make their way downwards as well, as shown in the fluctuating swellings observed above or below Poupart's ligament, which originate in tuberculous foci of the lower dorsal or lumbar vertebræ and pass down along the psoas muscles.

Many have failed to find bacteria in cold abscesses (Billroth, Ogston); others found tubercle bacilli alone or mixed with other bacteria. Hence it is claimed by some authors that the tubercle germ can cause suppuration, while others regard the process as only apparently purulent (Baumgarten). Pure "tuberculous pus" consists of a fine granular detritus of caseous material, fatty and granular cells, and few leucocytes. More typical pus is produced when mixed infection occurs, but even then the microscopic appearances of the pus are different from those of non tuberculous pus. Tuberculous abscesses are usually chronic, and perhaps the contents have been changed by the long stay. Inoculated into animals such as guinea pigs, the contents of "cold abscesses" nearly always produce tuberculosis.

"Serous abscesses" occur in connection with certain inflammations of the periosteum. The condition is also known as periostitis albuminosa and as periosteal ganglion. Flattened cavities form, containing a varying quantity, most frequently from 100 to 150 c.c., of clear, transparent, yellowish, viscid fluid like synovia or glycerin. The fluid contains albumin coagulable by heat and nitric acid, more or less mucus, and some fibrin. Pus cells are absent. Bruer, who collected twenty five cases, found the femur involved twelve times, the tibia eight times, the humerus twice, the ulna twice, and a rib once. The lesion was located at the epiphyseal junction seventeen times and in the middle of the shaft five times. It is thought that this form of inflammation may be either tuberculous or pyogenic in its nature, the peculiar morphology of the exudate depending on a secondary mucoid degeneration of pus cells or upon reabsorption of the leucocytes; or the exudate may be primarily serous, due to the peculiar action of the microbes.

The Size, Walls, Fate, etc., of Abscesses.—In size abscesses vary from the microscopic to those containing a litre or more of pus, such large accumulations are observed especially in the soft subcutaneous tissues and in preformed cavities like the pleural, the renal pelvis, etc. The writer once opened an abscess in the anterior abdominal wall, situated between its layers, which contained no less than four litres of yellow, creamy pus. This enormous collection developed in a girl seven years of age, who for a time previously had presented the symptoms of typhoid fever; gradually the abdomen began to enlarge and soon an excessive size was reached; the summit of the distention corresponded to the navel. The cavity, which occupied the whole extent of the anterior abdominal wall, did not appear to communicate with the peritoneal cavity. After the insertion of numerous drains, which converged at the navel and passed out at the pubes and the flanks, the symptoms began to improve, and complete recovery took place.

When pus accumulates in a preformed cavity the walls of the abscess are, primarily at least, those of the cavity. Abscesses in solid organs or tissues after a time generally become walled off from the surroundings by a layer of granulation tissue and fibrous tissue, to which the name "pyogenic membrane" has been given, on the supposition that this membrane secreted the pus. Pus may form, however, without any such membrane, which in reality represents the effort of the organism to circumscribe the action of the pyogenic agents and limit the destruction of tissue. The term pyogenic membrane is therefore an ill-chosen one.

Often there is not this tendency to definite circumscription, but the pus wanders or "burrows" in the direction of least resistance, soft parts like muscle yielding readily, whereas dense fibrous structures, like fasciæ, offer more resistance. Abscesses near the surface of the body tend toward the surface, and are then said to "point"; eventually spontaneous rupture and discharge of the contents may take place. Abscesses in organs with serous coverings often reach the surface, perforate the covering, and by the discharge of pus into the cavity cause diffuse inflammation of the serous membrane. Sometimes previous adhesive inflammation between two serous surfaces may prevent the escape of the pus into the cavity in which the organ lies, the pus eventually being discharged along other routes. Thus adhesions between the diaphragm and the lung precede the discharge of abscesses of the liver into the bronchi.

Instead of pus being discharged spontaneously, or after incision, it may be removed by absorption. This presupposes, in the first place, the destruction, neutralization, or removal of the pyogenic agent and the subsidence of the active inflammatory changes; the fluid parts are absorbed, the living leucocytes and wandering cells depart, and the dead cells undergo disintegration either by extra or intracellular digestion. Occasionally the solid parts of the abscess contents are not removed, but undergo inspissation and are changed into a crumbling, grayish material, which later may become infiltrated with lime salts and converted into a calcareous mass; it is also possible that inspissated pus may later undergo liquefaction. Absorptive changes like these are always associated with the formation of a well-marked connective tissue capsule, which separates the area from the surrounding tissue. Abscesses healing spontaneously may leave behind a mere scar, an encapsulated, calcareous mass, or more rarely a cyst. It is probable that pyogenic microbes may persist for some time in such areas in a condition of latency.

Embolic Abscesses.—Secondary or metastatic abscesses are those which are developed at a distance from the point of primary infection. They are properly called embolic also, and are usually multiple and small, hence often called miliary abscesses. They are always due to infectious organisms, and in most cases the infected emboli are derived from thrombi undergoing septic softening or from fragments of endocardial vegetations. It is also probable that the circulation in the blood of pyogenic organisms may result in the formation of multiple abscesses, in the same manner as the intravenous injection, in rabbits, of pure cultures of Staphylococcus pyogenes aureus is followed by miliary foci of suppuration. The presence in the blood of pyogenic organisms, with the formation of embolic or metastatic abscesses, constitutes the much-feared disease pyæmia. If one wishes to find the source of embolic abscesses in a given case, one follows back the circulatory current and searches for a vessel the seat of thrombosis and inflammation. Thus, if such abscesses

are present in the lungs, one is likely to find the source either in the sinuses of the brain, in the venous plexuses around pelvic organs, or in the peripheral veins. Embolic abscesses of the brain, heart, spleen, kidneys, etc., commonly have their origin in an infectious endocarditis —arterial pyæmia. In cases of multiple abscesses in which careful search fails to disclose the primary seat, the pyæmia is sometimes spoken of as cryptogenetic, its origin remaining hidden. Embolic abscesses of the liver are usually derived from the radicles of the portal vein, which become involved in such conditions as appendicitis and suppuration associated with hemorrhoids and with dysenteric and other ulcers in the intestines; infected emboli may also reach the liver through the hepatic artery in general pyæmia. Embolic abscesses are most frequently due to Staphylococcus and Streptococcus pyogenes, but Micrococcus lanceolatus, Bacillus mucosus capsulatus, and other bacteria are also often at work in such cases. Characteristic multiple abscesses, whose pus contains the fungus granules, also develop in the metastases of actinomycosis.

Symptoms.—The general symptoms of acute abscesses are those of a local infection, the intensity of the infection varying according to the virulence of the organism. There will be local pain, tenderness and swelling, and more or less fever and general disturbances due to the absorption of toxic substances. In streptococcus infection the general symptoms are often severe. It should be borne in mind that in the early stages of abscess formation the swelling may be firm in consistence, and that an exact etiological diagnosis is possible only after careful bacteriological examination. Chronic abscesses, in addition to the purely local symptoms, may in time induce amyloid degeneration of the internal organs.

Ludvig Hektoen

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ABSCESS. (SURGICAL.)—Clinical research and observation combined with bacteriological experimentation have demonstrated that the presence of pus is always sure to be accompanied by some form of bacteria. That these pyogenic bacteria stand in the relation of cause and effect to the pus production has not been absolutely proved. It has, however, been shown that they or their products, that is, the toxins which their chemical action produces, are capable of inducing, and do induce, a coagulation of tissue and a digestion by peptones which finally result in the formation of the abscess. Abscess formation is therefore the result of their action upon tissues and of the reaction which is induced in the body in the effort of self-protection.

The severity of the infection depends upon the character of the infecting micro-organism and upon the attenuation which age or environment has effected in the virulence of its toxins, while the reaction is proportionate to the resisting power or the vitality of the individual infected. Thus it has been found that the infection which results from the rupture of an abscess of long standing into the peritoneum is in some cases almost innocuous and the reaction very slight, although the pus contains bacteria which are endowed, under other circumstances, with a virulence that would produce a fatal infection. Under such circumstances and in operations upon collections of pus that are chronic in their mode of development, the greatest aseptic precautions should be employed to prevent infection by more virulent germs or those of a different character.

Such an advance in our knowledge of the causation and pathology of abscess formation has revolutionized our methods of treatment and necessitates an adaptation and revision of the nomenclature, as well as of the treatment, of these results of infection.

An abscess, when considered in the light of this new pathology cannot be comprehensively defined as a circumscribed collection of pus. That definition can be applied to the nidus or circumscribed points of infection from which the general infection may spread, but the cause, the bacteria, may have permeated the surrounding tissues or may have passed on farther through the lymphatics, and their toxins may already be producing a coagulation necrosis. The abscess, in its incipient stage, may thus be widespread in extent, and yet no pus be formed other than in the nidus.

Treatment, to be effective, must not be delayed till the abscess is fully formed. It must comprehend the facts demonstrated by pathology, and to be radical, thorough, and efficient it must deal with the incipient abscess. The cause must be removed before the infection expresses itself in the fully developed circumscribed collection of pus which would embrace the whole area infected. The old method of waiting till the abscess has formed and "pointing" has taken place, has had to give way to methods which destroy the infecting agent and assist nature in preventing its spread. The results justify the treatment. Recovery is more rapid and the drain upon the system is lessened, while in cases of grave infection the life of the patient can be saved in no other way.

From the surgical standpoint abscesses are classified in accordance with their situation, in reference to structures which determine their development and appearance, or in reference to an organ the vitality of which is threatened by their proximity. These relations influence their symptomatology and in a measure the method of treatment.

The symptoms that accompany the formation of an abscess are those of a localized acute suppurative inflammation. The area surrounding the point of infection becomes tensely swollen from the infiltration of the tissues by the outpouring of leucocytes. The surface becomes more or less glazed from the tension and is covered by a bright red blush. The increasing tension within brings ever-increasing pain in the nerves, which finally becomes acute, with a characteristic throbbing or boring sensation. As the pressure increases and the tissues become thinned out, "fluctuation" is recognized by the alternate pressure of the fingers. If the process is allowed to go on, the integument becomes whitish and thinned at one spot, that is, "pointing" takes place, and finally the abscess ruptures.

The constitutional disturbance is great throughout. There may be a rise and fall in temperature on alternate days that suggests malaria, from which the differential diagnosis has frequently to be made. When suppuration takes place there is either a chill or a sudden rapid rise of temperature. Just before "pointing" takes place the pain and febrile disturbance are very great. The rupture of the abscess is followed by a subsidence of both local and constitutional symptoms.

The tendency of all abscesses or infections is to spread in the direction of least resistance. They have therefore been classified in relation to the structures which tend to limit their spreading and to direct their development into subcutaneous or superficial, and subfascial or deep abscesses.

The deep or subfascial abscess is generally limited by the deep fasciæ and extends in the direction of least resistance beneath that structure. It may be limited by the periosteum of the bone, in which case it forms a subperiosteal abscess. It may dissect its way between the muscles, since the loose cellular and connective tissue which separates them readily yields and forms the path of least resistance. It may follow the sheaths of blood vessels or along nerve trunks. In dealing with deep abscesses the surgical anatomy of the part must be duly considered, and the directions in which the abscess may extend examined with this idea in view.

The symptoms of deep suppuration differ from those already described in coming on more gradually. The first symptoms are of a subjective nature. There is no immediate superficial swelling, the normal contour and outlines of the part are not altered. An œdema may be the first superficial sign, followed by tenderness and red-

ness, and as the inflammation approaches the surface all the symptoms gradually appear. According to the region in which the abscess has formed and the extent to which adjacent organs are involved, the pus will be found to contain fragments of necrosed bone, or urine, or bile, or intestinal contents, with frequently an odor that is very characteristic.

These deeper abscesses are generally chronic. An acute deep seated suppuration is, however, not uncommon. The chronic abscess is most frequently the result of a tuberculous infection, or the deep-seated focus may be the remnant of an acute disease. Such suppurations and abscess formations are seen as the sequelæ of typhoid fever, of influenza, or of any of the infectious diseases.

Chronic suppuration, or "cold abscess" as it was formerly termed, is most frequently a result of tuberculous infection. The psoas abscess illustrates the result of a tuberculous infection in which the pus enters the sheath of the psoas muscle, usually from a focus in a vertebra, and, following the line of least resistance, burrows down within its sheath and finally "points" just above or below Poupart's ligament, often on the inner surface of the thigh. Another example of a deep-seated chronic abscess of this character is seen in the post-pharyngeal region. Here it arises from a focus of tuberculous disease in the cervical vertebræ and is guided by the deep fasciæ of the neck and the sheaths of the blood-vessels, and often points in the lower portion of the neck. The abscesses of Pott's disease are to be grouped in this category. In fact all foci of infection which are introduced by any cause beneath the deep fasciæ may give rise to suppuration with the formation of abscesses, which can be classified only as deep abscesses or given names which correlate them with the organs the vitality and function of which they endanger.

As illustrations of this method of nomenclature we have the perinephritic abscess, the ischiorectal, the perityphlitic, and those which form in the pericardium or in the pleura.

The treatment of these chronic forms of suppuration, these deep-seated subfascial abscesses, is identical with that of abscesses in all situations. The strictest antisepsis and asepsis should be employed. The bacteria that produced these abscesses have had their virulence attenuated by the chronicity of their development and the resistance offered by the tissues that surround them. The reacting and resisting powers of the tissues have, however, been weakened, while the conditions present in the abscess cavity are typical, for the rapid development of other forms of pyogenic bacteria. A mixed infection should be carefully guarded against, and every precaution employed to prevent the entrance of other more active and more virulent forms of bacteria. The parts should be carefully scrubbed and prepared with antiseptic washing. The operator's hand should be as clean as for a major operation, and the instruments and surroundings should have all the care given to them which is essential to an aseptic operation.

In contrast with the older methods of treating abscesses the surgeon does not wait till "pointing" has taken place. That means that the abscess and infection have, in a subfascial abscess, extended in the direction of least resistance, beneath the deep fascia, as far as is possible, and have at last been forced to break through that fascia and come to the surface. As a consequence all the damage that is possible has already taken place, and the full extent of the infection has been reached. This is what operation should prevent. It must therefore be early and radical. As soon as the presence of infection and the danger of abscess formation are evident, operation should be undertaken. The detection of deep-seated fluctuation or of deep induration, and the presence of localized pain and constitutional symptoms, are sufficient indications for early operation. Such intervention is essential in many cases to the preservation of the integrity of the organ involved. As an instance the ischiorectal abscess may be cited. Early incision in these cases prevents the rupture of the abscess into the bowel and the subsequent formation of a fistula. It also prevents the involvement of the entire region and the formation of a horseshoe abscess cavity about the rectum. This is especially liable to occur because the connective tissue is very loose and its blood supply limited.

The free incision is planned so that drainage can be provided for at the most dependent point; that is, at the point where, when the patient is in the position assumed during the after-treatment, the drain will enter at the bottom of the pocket. Free drainage of the entire cavity is most essential in the treatment of abscesses. In many cases it is necessary to make more than one incision. When free, dependent drainage cannot be secured, pressure must be applied, so that no pockets of undrained pus shall remain. If an abscess is so situated that it is impossible to secure dependent drainage, the thorough evacuation of the pus may be secured by employing a sterilized boroglyceride. This preparation has a greater specific gravity than pus, and will displace it in the depths of a sinus or abscess cavity. I have thus been able successfully to drain a pelvic abscess and the sinuses that diverged from it, in a case in which the septic condition of the patient made operation impossible.

After the incision has been made and the pus evacuated the cavity should be carefully inspected and its relation to vital organs and structures determined. Then a sharp curette is employed to remove all sloughs and the infected granulation tissue which forms the inner wall of the cavity. The thorough removal of this infected tissue is essential, for in it are many bacteria that are capable of setting up further coagulation necroses and of developing new abscess cavities. In acute and severe infections it is often essential to follow up this infected tissue into areas that are simply infected and inflamed, and where pus and abscess cavities have not yet been formed.

After the thorough use of the curette bleeding may be checked by packing the cavity with sterile gauze, which, if the case is one of chronic suppuration and the symptoms are not acute or the infection very virulent, can be removed and the wound closed, firm pressure being applied to hold the abscess walls in close apposition. This method of treatment in suitable cases is followed by primary union. Perfect asepsis and the absence of irritation and oozing in the wound are, however, essential to its success. The more certain plan is to provide drainage. When the infection is more virulent it is necessary to use antiseptic solutions to destroy the bacteria in the wound. Their action upon the tissues is, however, harmful, and drainage thus becomes essential. Where the infection is still more severe and there is great induration, the wound should be irrigated with a 1:1,000 or 1:5,000 solution of bichloride, to be followed by sterile water. The wound is then packed with wet bichloride gauze wrung out of a 1:5,000 solution; over this is applied on the exterior more wet gauze covered by oiled silk, mackintosh, or some impervious material which forms an antiseptic poultice by retaining the heat of the body. When a less vigorous action is needed, the protective may be omitted and the moisture allowed to dry out. Or simple sterile gauze may be employed in sufficient quantity to absorb the exuded serum and keep the wound dry. Free drainage or packing with gauze which is frequently changed effects the same purpose by absorbing from the wound the moisture essential to the development of the bacteria. When, however, the infecting bacteria are very virulent, this is insufficient and it is necessary to use more active germicidal agents. The use of iodoform gauze should be confined to tuberculous abscesses. In these it has been found to exert an apparent specific influence upon the bacteria. The action of the wound secretions liberates from it free iodine, which is a decided irritant. It would therefore seem well to avoid the employment of iodoform gauze in cases in which such an irritant action is not desired.

Of the acute forms of abscess formation the spreading abscess accompanied by septic lymphangitis is the most dangerous and requires the most prompt radical and thorough treatment. The infection usually takes place through some trifling wound of the extremities. It

spreads through the lymphatics and may go unnoticed, and the primary wound may heal before the patient's attention is directed to the condition by swollen and painful glands that have become hyperæmic from their redoubled activity in combating the poison. The glands are found swollen at the elbow and in the axilla in case of infection in the hand, while the courses of the lymphatics are marked by red lines. Although the abscess is located in the hand, it has in a sense spread throughout the lymphatics. The infection is there, the bacteria and their toxins are there, and the incipient abscess, unless prompt treatment is applied, will develop throughout this entire area.

The treatment is identical in principle with that of all abscesses. The local focus of infection must be opened and thoroughly curetted; other foci of suppuration, no matter how many they are, should be opened and as much of the infected tissues as possible removed. The glands should, however, be respected as long as possible, until suppuration is actually present, for they are the bulwarks which nature is erecting to prevent further invasion. Their swollen, congested condition is due to their increased activity, and unless their vitality is endangered they should be preserved.

In mild cases the opening of the original focus of infection and its thorough treatment by an antiseptic poultice dressing often prove sufficient, when combined with the application externally over the inflamed lymphatics of a fifty-per-cent. ichthyol ointment. Severe infections, with multiple foci of suppuration, demand multiple incisions with wet antiseptic dressings frequently changed, and, in some instances, continuous irrigation with antiseptic solutions. In spite of all of these methods of treatment, the infection may become so serious that amputation is necessary to save the patient's life. Either a part or the entire limb may have to be sacrificed to rid the system of the source of infection, and even then the patient may succumb.

The essentials in the treatment of abscesses are, therefore, free incisions, free drainage, thorough cleansing and curetting, with the employment of aseptic or antiseptic washes and dressings, as the severity of the infection indicates. In all cases of abscess formation, tonic systemic treatment is indicated, and frequently, unless such treatment is carefully carried out, recovery will be very tedious, especially in cases of chronic abscesses.

Among the cutaneous and superficial abscesses are to be classed those that lie in the skin itself, such as boils, carbuncles, and the less serious forms of pustules. The latter are seen as the acne pustule, and they range in size from a pin's head to a pea, according to their period of development. They are the result of infection in the hair follicles or sweat glands, with the blocking up of the duct.

The next form of cutaneous suppuration, in point of frequency and freedom from serious results, is the *furuncle* or *boil*. It differs from the pustule only in the depth to which the infection penetrates and the severity of its symptoms, which result from the increased difficulty in "pointing" and the severity of the coagulation necrosis which the toxins of the infecting bacteria produce. The symptoms of abscess formation are present, but in a mild form. As the process of destruction and the breaking down of the tissues proceed the boil becomes sore and tender on pressure. A crust forms over the duct When it is removed a probe can be passed down into the abscess, even before it has begun to discharge. The suppuration increases, and finally the core, or the result of the coagulation necrosis, is expelled, when the cavity heals by granulation. This is the natural process without treatment.

Since a series of boils may follow in the same individual, a condition is determined called *furunculosis*. Constitutional and prophylactic treatment are therefore as essential in many instances as surgical treatment. Frequent baths and changing of underclothing, with careful care of the nails and the avoidance of scratching, are among the preventive measures, while, when the boils are in process of formation, antiseptic washes should protect the surrounding skin. An ounce of sulphonaphthol in a bathtub of warm water makes a mild antiseptic bath that is not injurious and that cleanses the skin of the superficially located bacteria.

Boils may be aborted, when they are small and are situated superficially, by applying a few crystals of pure carbolic acid on a glass rod or piece of wood; or, when the disease is further advanced, by the injection into the parenchyma of a three-per-cent. solution of carbolic acid in amounts proportionate to the size of the boil. This method is somewhat painful and not always successful.

The expectant treatment should be employed only when a scar is to be avoided and no organ is threatened, and when it is too late for abortive treatment. An antiseptic poultice, gauze or cotton wet in 1:3,000 bichloride solution under a protective, should be applied over the boil and the cavity should be syringed out daily until the core is discharged, when the cavity may be packed and an occlusive dressing (cotton held in place by collodion) applied.

The crucial incision will frequently abort a boil and permit an antiseptic in the dressing to reach the seat of infection and destroy the bacteria. When the disease is further advanced free opening, curetting, and subsequent treatment as for any other abscess constitute the most rapid and radical method and furnish the best results. Any of these operations can be rendered painless by the employment of infiltration anæsthesia or by the subcutaneous injection of a two-per-cent. solution of eucaine B or cocaine. These injections should commence outside the inflamed area, as the increased pressure causes great pain.

A *carbuncle* is the result of an infection by bacteria that enter the skin in the same manner as they do in the case of a boil. The conditions under which they develop are responsible for the difference in the symptoms and the gangrenous inflammation and sloughing that take place in the subcutaneous cellular tissue. The conditions which predispose to carbuncle formation are the location of the infection in the thicker portions of the skin, where it is difficult for the pus to find a mode of exit, and hence it spreads, causing pressure and coagulation necroses over large areas, and pointing through the numerous columnæ adiposæ, which offer its only points of exit through the toughened skin. It is distinguishable by the extent of the tissues involved and by the multiple points or heads which first show themselves. Pain is not so marked a symptom and is not commensurate with the extent of the suppurative process.

The treatment is antiseptic, and always should be in a measure operative to permit the outflow of pus and the action of an antiseptic on the foci of infection. The amount of operative interference demanded varies with the gravity of the case, from a deep crucial incision, with or without curetting and an antiseptic poultice, to complete excision of the entire carbuncle. The latter is of course reserved for the severer cases, while there are varying degrees of operating which depend on the extent of the infection. All parts should be thoroughly exposed and subjected to the action of antiseptics.

Felons, panaritium, vary in degree and in their situation. They are abscesses that form in the fingers and hands. The varieties are the cutaneous, tendinous, and subperiosteal, together with a more general form which is known as a palmar abscess and may be either superficial or deep according to its relation to the palmar fascia. It is of special importance because it endangers the integrity and function of the hand.

The various forms of felon are named according to the structures in which they originate. Their complications, sequelæ, and gravity depend upon these relations. The subperiosteal felon may destroy a phalanx or involve an articulation. The tendinous felon may spread through the tendon sheaths, and involve these spaces in the hand, if the primary disease is in the thumb or little finger. The cutaneous felon is liable to produce, as are all the others,

lymphangitis and possible suppuration in the glands of the elbow and axilla.

All of these panaritium cases demand radical antiseptic treatment: early deep incision down to the seat of the suppuration, curetting, antiseptic washing, in many cases packing with gauze wrung out of a 1:2,000 bichloride solution, and the application of an antiseptic poultice till the infection is gone. Prompt treatment of this character will save many fingers and hands that are of the utmost value to those most generally afflicted—the working classes. Carbolic solutions have a tendency to produce gangrene in the extremities and should be avoided in these cases. Bichloride solutions should be employed according to the dermal irritability of the individual. If too strong they may produce an irritation of the skin, and even poisoning. *Charles Lester Leonard.*

ABSINTHISM.—A term applied to the train of morbid symptoms following the abuse of the liquor called absinthe.

In its general features absinthism is almost identical with the alcoholism brought on by the immoderate use of any other alcoholic beverage (see article *Alcoholism*, under the heading *Insanity*); and some observers have even doubted whether any special and peculiar symptoms could be attributed to any of the non-alcoholic ingredients contained in the liquor. Nevertheless, according to most authorities, not only the evil effects of intemperance appear earlier in those addicted to the habitual and excessive use of absinthe than they do in the case of abusers of other alcoholic drinks, but these effects are in themselves of a severer nature, and there is, besides, a more marked disturbance of the nervous system in its various parts. Vertigo, severe headaches, a condition of stupor and of apathetic listlessness, terrifying hallucinations, and epileptiform convulsions are particularly noticeable among the symptoms belonging to the absinthe tippler, and this liquor is especially prone to bring on an early condition of mental decay, and seems to be *facile princeps* in its power to enslave its victim. That the active principles of absinthe (Artemisia absinthium and its congeners) are the agents in causing the special toxic effects of the liquor, has been pretty well established by Marcé in his experiments on dogs and rabbits.

Huntington Richards.

ABSORPTION.—Gould, in his "Medical Dictionary," defines absorption as: the permeation or imbibition of one body by another; the process whereby nourishments, medicines, morbid products of tissue metamorphosis, etc., are taken up by the lymphatic and venous systems. Foster defines it as "the inbibition of nutrition or other materials by a living organism; the process of taking waste or effete material into the general circulation." In the limited sense of this article, and as usually accepted in physiology, absorption is merely the process by means of which nutritive material is taken from the digestive tract into the circulation.

Certain fluids when brought into contact with one another will mix until the liquids present a uniform composition, and the passage of the molecules of the one liquid into the intermolecular spaces of the other has been named "diffusion." When the same or similar two liquids are separated by a membrane, this diffusion takes place through the membrane and is then called "osmosis."

For a long time osmosis was supposed to be sufficient to account for all the phenomena of absorption, the process seemed so delightfully simple, but careful studies revealed the fact that while dead membranes, fluids, and gases under certain definite conditions obey equally definite laws, osmosis fails to explain the actions of living organs. Theories of electrical action and of differential filtration demonstrate only more clearly the complexity of the function of living absorbing surfaces. Living cells obey their own laws, and they are laws of life, not of mechanics. As the unicellular animal ingests, digests, absorbs, and excretes, and knows what it wants and what it has to do, so in the complex higher animal each cell retains all these functions, while the differentiation of the organs has imposed upon each the additional labor of doing something for the general well-being of the whole organism. The work assigned to the cells of the different parts of the digestive tract concerned in absorption is first to keep themselves in good condition; secondly, to pick out from the contents of the tract such substances as the body wants, and pass them into the circulation. It is safe to assert that normal absorption is a living, not a mechanical act, and that osmosis, as a factor in these phenomena, must not be taken into account. In pathological conditions, however, in conditions in which the separating membrane has been injured or its vitality lowered, osmosis may well come in as a strong factor in swellings, effusions, lymph accumulations, and all the phenomena usually designated as poor absorption; here we shall have to imagine a fight between the osmotic and the vital processes, the latter constantly tending to check the action of the former, until recovery takes place and osmotic action has ceased.

In a healthy body the skin can be excluded as an organ of absorption; in spite of the many careful experiments made pro and con, the weight of authority to-day rests with the assertion that under normal conditions the skin is passive so far as absorption is concerned. The same must be said about the mucous membrane of the mouth and œsophagus, for although we know that violent poisons can be and are taken up by the mucous membrane of the mouth, under ordinary conditions food does not stay there long enough to allow of any absorption to take place. That limits the absorbing surfaces of the human body to the mucous membranes and allied structures of the stomach, and the small and large intestines.

While the food eaten determines the length of the digestive tract, the absorbing surfaces bear a definite relation to the bulk of the body and explain why the body stops growing after a certain size has been attained. During a given limit of time the absorbing surfaces increase as their square while the body increases in bulk as its cube. In other words, if we assume that the absorbing surface equals 2, and the body bulk equals 2, then by the time the former has grown to equal 4 the latter equals 8; and when the former has increased again to 16, the latter's bulk is 512. It is easy to see how the growth of bulk is checked by the limitations of the absorbing surfaces.

The substances to be absorbed are peptones, glucose, and emulsified fat, the products of digestion, besides water and different salts which have remained unchanged.

The stomach has no specialized organs of absorption, but its whole mucous membrane absorbs materials digested in its cavity, peptones and glucose. The older view which made the stomach practically the only organ worth mentioning of the digestive tract, and took it for granted that its function in the absorption of peptones, glucose, salts, and water was of proportionate importance, has been slowly changed by the results of modern experiments. Without going to the other extreme view which makes the stomach merely the temporary receptacle for food, these experiments prove that absorption of the above named substances does take place, but only to a limited extent. Of the carbohydrates, dextrose, lactose, maltose, and saccharose, even dextrin, is absorbed by the mucous membrane of the stomach, and the more concentrated the solutions, the more marked is the absorption. Peptones are absorbed slowly and apparently with difficulty, while condiments and alcohol increase distinctly the absorbing power of the stomach.

Perhaps the most interesting and least noticed fact brought out by these experiments is, that practically *no* water is absorbed by the stomach, but that all passes into the intestines; on the other hand, alcoholic solutions are readily taken up. This fact may ultimately help to explain why water is the beverage most desired when men are thirsty, and why something mixed with the water seems necessary when people, not thirsty, gather and drink for social enjoyment.

Peptones, glucose, and emulsified fats are absorbed

mostly in the small, and to a limited extent in the large intestines. Throughout the large and small intestines we find organs specialized for absorption, viz., the villi and the solitary glands. The former are most numerous in the duodenum and jejunum, the latter in the ileum. Throughout the large intestines we find solitary glands, but no villi, irregularly scattered, the largest numbers in the cæcum and appendix vermiformis; and their limited number, together with the well-known high absorbing power of the large intestines, leads us to think that its mucous membrane is, like that of the stomach, an important factor in absorption.

The villi, little cone-shaped protuberances in the mucous membrane, have a dense network of blood capillaries just underneath their epithelial covering, while a lacteal duct occupies the centre of the cone. The solitary glands have a dense lacteal plexus beneath the membrane and a limited supply of blood capillaries. All the blood capillaries of the intestinal tract are radicles of the portal vein, while the lacteal ducts and capillaries are radicles of the abdominal lymphatics. The villi, however, are the principal organs and carry the bulk of the peptones and sugars into the circulation directly, while the emulsified fats absorbed are poured by the way of the lacteals and abdominal lymphatics into the receptaculum chyli, and from there through the thoracic duct into the left subclavian vein.

How much the peptones absorbed are changed in their passage through the epithelial cells of the villi, and how much additional modification takes place in the capillaries and veins before the absorbed material enters the liver, is as yet a matter of conjecture. The knowledge that everything ingested, with the exception of fat, and water enough to emulsify the fat, has to pass through the liver before the body can make use of it, will probably increase our respect for that long-neglected and much-abused organ.

The emulsified fats are taken up by the epithelial cells and passed into the stroma of the villus; but whether directly into the delicate lymph channels which traverse it and finally unite to form the lacteal, or whether the leucocytes, so abundantly found in the stroma, carry the small fat globules from the epithelial cells directly into the lacteal, is yet an unsettled question. Under ordinary conditions only fat enters the lacteals, while peptones and sugar find their way into the blood capillaries; but that does not preclude the possibility that after an excessively fat meal, a trace of fat can find its way into the blood capillaries, as well as that, in cases in which an excess of meat and carbohydrates has been eaten, a trace of either can be found in the lacteals.

The bulk of the fats ingested is absorbed in the form of an emulsion; the small amount which is broken up into fatty acid and glycerin is probably absorbed with the peptones and glucose.

The absorbing power of the small intestines is about equal to the task of taking up the quantity of fluid formed by the action of the digestive ferments plus the quantity of fluids secreted by the pancreas, liver, and intestinal glands, and thus, as these quantities combined do not represent the total amount of fluid present, the contents of the small intestines remain fluid throughout their entire length. In the large intestines the conditions change, the absorbing power is high, secretion and digestion are limited, and, as a consequence, the contents become more and more pasty as they near the rectum, until finally the fæces contain that portion of the food ingested which has escaped digestion and absorption. The absorbing power of the large intestines is not limited to substances prepared by the action of the digestive fluids, but it can absorb undigested food, such as white of egg; and nutrient enemata, based upon this knowledge, have saved the lives of many patients.

The final test of the activity of absorption as well as of digestion will be a chemical and physical examination of the fæces, a proceeding perhaps not quite as agreeable to the physician as an analysis of the contents of the patient's stomach after a test meal, but an innovation which will be accepted with heartfelt gratitude by all whose digestive tract needs the services of the physician.

Julius Pohlman.

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ACANTHACEÆ (Acanthus family).—A large family, related to the Mints and Vervains, but unimportant except for its very rich ornamental properties. Many species have been utilized in the materia medica of British India, and the properties of Adhatoda (see *Vasicine*) are very peculiar. The principles are mostly resinous and amaroidal, with a few alkaloids, and all the recorded actions and uses, except those of *Adhatoda*, are rather indifferent.

H. H. R.

ACANTHOSIS NIGRICANS.—(Synonym: Dystrophie papillaire et pigmentaire [Darier]). A disease of the skin and mucous membranes characterized by hyperpigmentation and papillary hypertrophy, developing in the course of an abdominal cancer.

The first recorded case of this disease occurred in a patient in Dr. Unna's Clinique for Skin Diseases in Hamburg, and was described by the present writer in the "International Atlas for Rare Skin Diseases," No. 4, Plate X., in 1889. Since then cases have been observed in France, Austria, England, and Russia. Couillaud,* in a monograph published in 1896, was able to record thirteen cases. At the Twelfth International Medical Congress, Moscow, two additional cases were described.

The disease usually begins with a slaty or brownish discoloration of the skin of the neck, about the genital organs, and the umbilicus. In other cases the first symptom to attract the patient's attention is the papillary or condylomatoid proliferation affecting the mucous membranes of the mouth. Other regions that may be affected are the flexor surfaces of the extremities, the axillæ, and the inframammillary region, the anal region, and in women the vulval and vaginal mucosæ. A striking feature of the distribution of the disease is its almost perfect symmetry. The pigmentation varies from a light gray to a bluish-black in color. It occurs over large areas and fades at their borders into the normal color of the skin. It is generally coextensive with the papillary hypertrophy, but sometimes appears as a precursor of this condition. It has never been noticed on the mucous membranes.

The papillary hypertrophy varies in degree from a slight prominence of the normal areas of the cuticle to warty excrescences that may attain an elevation of a centimetre. It occurs in extensive patches in the regions noted and its borders merge insensibly into the normal skin. The patches are always dry, there is no exudation even from pronounced filiform excrescences, and they impart a harsh grating sensation on palpation. On pinching up the skin the epidermis is seen to have lost its elasticity, but the affected regions are freely movable over the subcutis. There is no appreciable desquamation from the affected areas. On the mucous membranes the papillary elevations may be discrete or they may occur in patches. The excrescences sometimes attain a very considerable size, and in appearance and consistency are strikingly like venereal warts, but, unlike them, do not bleed readily on palpation.

In some cases of long duration, changes in the appendages of the skin have been noted. The nails of the fingers and toes become dry, cracked, and misshapen. The hairs on the head and over the entire body become dry and fragile and may fall out spontaneously, producing a total alopecia.

Anatomy and Pathology.—Under the microscope changes corresponding to the clinical picture are found. The horny layer appears somewhat thickened; the granular layer shows several rows of keratohyaline cells; the rete Malpighii is the seat of a hypertrophy which in

* Dystrophie pap. et pig. ou acanthosis nigricans, Paris, 1896.

some sections attains the enormous dimensions seen ordinarily in common warts, and its lowest layer contains great quantities of pigment. The papillæ are elongated, sometimes attaining a length of 6 or 8 mm., and often ramify, following the digitations of the epithelium above them. They show no evidence of increase in width. The subpapillary layer and the cutis itself show but very slight changes—a moderate increase in the number of emigrated cells, of mast and pigment cells.

In most of the cases there has been more or less positive evidence of cancer affecting the abdominal organs. In the two cases in which an autopsy was obtainable there was an extensive carcinosis of the abdomen, which, while it spared the adrenal bodies, was especially noted as involving the lymph glands in close proximity to the large sympathetic ganglia. There is no doubt that the disease is directly dependent on the existence of abdominal cancer, but whether it be a cutaneous manifestation of a peculiar cancer intoxication or whether it be due to changes induced in the great sympathetic ganglia through the pressure of the tumors on them, or to the combined action of both these causes, is a matter that future investigation must determine.

Diagnosis.—Ichthyosis, pityriasis rubra pilaris, and keratosis follicülorum (Darier's disease) are the only diseases which may bear even a remote resemblance to acanthosis nigricans. Ichthyosis is a mild congenital disease, persists throughout life without producing any general disturbances, is located chiefly on the extensor surfaces, never affects the mucous membranes, and is characterized by constant desquamation in more or less extensive scales. Pityriasis rubra pilaris, sometimes occurring in extensive sheets about the great flexures and presenting the peculiar discoloration common to many hyperkeratoses, may suggest acanthosis nigricans, but in all other respects there are more points of difference than of resemblance between the diseases. Darier's disease is differentiated by the limitation of the affection to the follicles, the non-involvement of the mucosa, the peculiar greasy character of the affected surfaces, and the occasional occurrence of large nodular masses from which a foul secretion is discharged. The differentiation from the various pigmentary affections of the skin need not be entered into.

The *prognosis* of the disease is, of course, that of the underlying cause—the abdominal cancer; that is, it is hopeless. In some of the cases the cutaneous manifestations have undergone a varied course, probably depending upon changes in the location or size of the tumors in the abdomen. In my own case there was an almost complete disappearance of the affection of the skin and mucous membranes shortly before the patient died.

Sigmund Pollitzer.

ACARDIUS. See *Teratology*.

ACARI. See *Arachnida*.

ACAROIDES GUM. See *Zanthorrhœa Resin*.

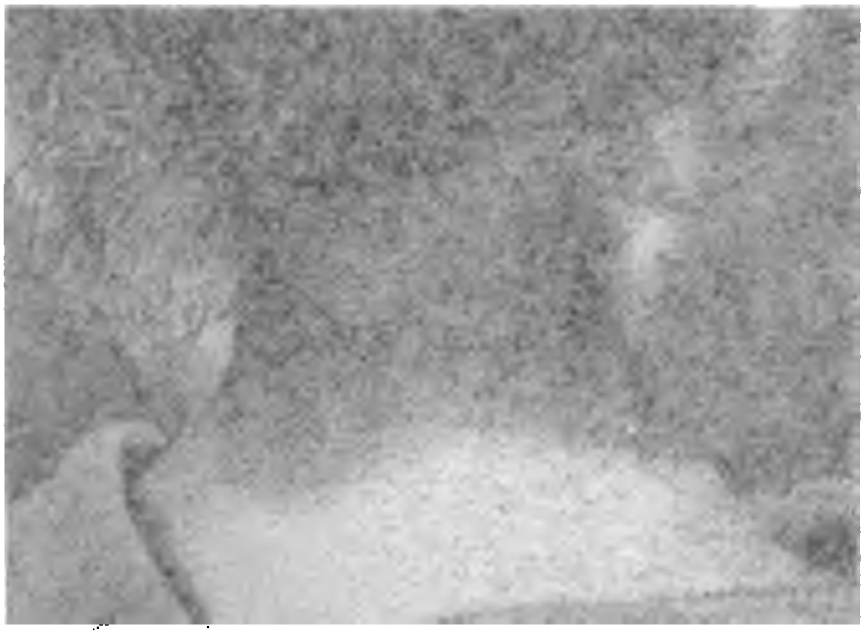
ACCLIMATIZATION.—When any animal, brute or human, is removed from the environment to which he and his ancestors have long been accustomed, a considerable disturbance of the whole economy is liable to ensue. The process of evolution has developed certain organs and certain functions in accordance with the requirements of those circumstances under which his race has found itself, and when he is suddenly transplanted into new conditions some of his faculties become without occupation, while others hitherto uncalled upon, and therefore undeveloped, are suddenly subjected to a demand to which they are quite unable to respond. The process of accommodation of the individual to new conditions of climate is known as acclimatization or acclimation. These conditions include temperature, moisture, morbific germs, elevation, sunshine, food, and other less tangible factors. Such elements as are connected with the social rather than the natural environment, as, for instance, education, the standard of public morality, and the avocation or means of livelihood, while in any radical change that they may undergo profoundly affecting the individual, are yet to be held distinct from the conditions to which acclimatization properly refers.

No other animal is so facile in his accommodation to changes of climate as man. The lower animals and plants often do not recover for several generations from the effects of transplantation. The Societé d'Acclimatisation of Paris has for years been carrying on, in its gardens, an extensive zoölogical experiment on the domestication of foreign animals and plants which it is believed can be made useful to European countries. The record of its failures and successes is embodied in the numerous volumes of its reports. Man's comparative immunity from the disastrous effects of changing climate is due in part to his ability, by an intelligent prevision of the dangers which are to beset him, of guarding against them. The records of arctic explorers present abundant eivdence of the ability of the denizens of temperate climes to endure winters in which the thermometer averages from 40° to 50° F. below zero. On the other hand, Europeans have lived in health and cheerfulness on the banks of the Senegal when the thermometer in their tents stood at from 120° to 130° F. Men endure extremes of barometric pressure ranging from that of several atmospheres, as found in caissons, to the tenuity of the air experienced at great elevations. In the Himalayas men have lived at the height of 15,000 feet, and Humboldt even went to the elevation of 19,286 feet, where he remained for a time without ill effects; but where no animal but a dog would follow him, and this creature quite lost the power of barking.

The differences in the facility of acclimatization at various points in the same latitude are shown by an article reprinted in the *Popular Science Monthly* for July, 1884. Between 30° and 35° N. latitude, Europeans acclimate much less readily than in the same latitudes south. Algiers, for instance, is vastly more difficult for the European to live in than Cape Colony, yet both places are about latitude 35°. The Argentine Confederation and New South Wales are more healthy than the East and West Indies, which are of the same latitude. The mortality of the French and English troops has been found to be about eleven times as great at foreign stations in the northern as at those in the southern hemisphere. The chief cause of the difference is in the prevalence of miasmatic fevers so deadly to Europeans. Those fevers in the northern hemisphere occur even in high latitudes, while south of the equator they do not extend beyond the tropic. The island of Tahiti, for instance, about latitude 18° S., is quite exempt from these fevers. The records of the French and English soldiers on foreign service show, in South America, a sickness from malarial fevers of 1.6 in 1,000 men per annum; while in a similar latitude in the northern hemisphere, the number of such cases annually is 224 per 1,000.

To persons removing from one point to another within the temperate zone, one principal obstacle to acclimatization is change (especially diminution) in barometric pressure. Many persons on going to an elevation of not more than 6,000 feet experience a sense of constriction in the chest as well as across the liver and stomach. The pulse is quickened, as is also the respiration. The individual sometimes feels that he cannot take a long breath, and is often testing himself to see if he can do so, but the act does not relieve the air-hunger. Slight exertion causes fatigue and sleep is disturbed and fitful. If there was any pre-existing heart trouble, the condition may soon become perilous. Anything like a congestion of the internal organs adds to the danger of ascending to high altitudes. If the unpleasant symptoms continue after a day or two of perfect rest, it is advisable to make no further attempt to secure acclimatization.

The practical questions of greatest importance connected with acclimatization are those relating to the colonization of Anglo-Saxon peoples in tropical countries, which, while they have long concerned our English



Acanthosis Nigricans. (Case of Dr. S. Pollitzer; from the International Atlas of Rare Skin Diseases.)

Fig. 1. Shows the roughened and discolored condition of the neck.

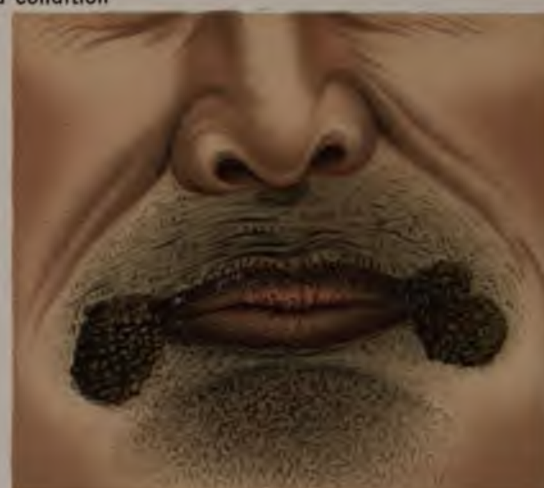


Fig. 2. Shows the discoloration about the lips and chin, and the condylomatoid proliferation at the angles of the mouth.

Fig. 3. Microscopic section through one of the condylomatoid masses at the mouth.

Acanthosis Nigricans. (Case of Dr. S. Pollitzer; from the International Atlas of Rare Skin Diseases.)

brethren, have come to possess a new interest for Americans in connection with our recently acquired possessions.

To the question, "Can Anglo-Saxons ever become completely acclimatized in the tropics?" a more or less guarded negative reply has been given by probably a majority of the most eminent authorities. This, it will be observed, does not mean that Anglo-Saxons cannot live in the tropics under conditions of special caution. It does imply, in the minds of its advocates, that Europeans can never expect to perform the same work under the same conditions as the natives. If this be the case, it presupposes the continuance of a distinctively menial or servile class as a permanency, which appears to be inconsistent with the theory of a purely democratic colony.

In favor of the pessimistic view regarding tropical acclimatization are urged the high death rate, the physical deterioration, and the reduced fertility of Europeans in the tropics. The first two of these considerations are certainly matters in which the improved sanitation of recent times may be expected to count for much. In fact, the annual mortality of European troops in India, which prior to 1859 had been 69 per 1,000, has now fallen to 12 per 1,000. The death rate of European children in India is considerably less than that of native children, and in some colonies compares favorably with that in many districts of Europe.

Whether, as has been sometimes claimed, white families in the tropics are likely to die out, is difficult of demonstration, because the stock is liable on the one hand to be reinforced by fresh European immigration, or on the other to be deteriorated by mixed marriages. But a paper presented at the Seventh International Congress of Hygiene and Demography by Sir Clements Markham shows that families of pure European blood had been settled in tropical places for more than two centuries without any deterioration, mentally or physically, of the later, as compared with the earlier representatives.

Regarding fertility as affected by removal of Europeans to the tropics, great diversity of opinion has existed. The analogy of plants seems to suggest a loss of fertility, at least temporarily, from a change of climate. For example, the chrysanthemum is said to have remained infertile for sixty years after its transplantation from China into France, so that the seed had to be continually imported. But after that time fertility began to be regained, till now the species propagates itself. European fowls, which when first brought to Bolivia became sterile, later regained their fecundity.

Regarding the human species, however, we are liable to error in judging from cases in which infertility is due to crossing of the breed with inferior races; or when possible lack of fecundity is overcome by fresh European admixture. Yet, as against a permanent sterility of pure European families in the tropics there are abundant instances. It is said that Spanish women in Guayaquil, at a temperature rarely below 83° F., are exceedingly prolific, and that the French have a higher birth rate in Algeria than in France.

In general, we may say that it is not temperature or climate intrinsically which is the obstacle to acclimatization. Physiology has shown the marvellous adaptability of man to withstand the widest ranges of thermometric variation. Moreover, anthropologists agree that mankind is all descended from one primitive stock. Hence man *has* acclimatized himself, as a matter of fact, wherever by successive migrations he has permanently occupied new fields.

The only important obstacle, then, to acclimatization is pathogenic organisms, and not temperature.

The diseases to which a European is especially subject on removing to the tropics are yellow fever, dysentery, hepatitis, anæmia, and malaria. The first of these, yellow fever, constitutes the greatest immediate danger for the unacclimated stranger. The Creole population, as is known, are largely exempt from susceptibility to this disease, though even they, after having resided for a time in the temperate zone, have to go through an acclimatization on their return before they are safe from the disease. Their acclimatization is more quickly accomplished, however, than that of the European. Immunity against this fever is gained by a previous attack, and also by having passed through an epidemic of it, even without having contracted the disease. The time necessary to secure absolute safety against yellow fever is variable. The other tropical diseases which impede acclimatization—dysentery hepatitis, etc.—afford no security against yellow fever.

Dysentery, which is perhaps, next to yellow fever, the most fatal obstacle to the acclimatization of Europeans in the tropics, is rarely, except in great epidemics, fatal at the first attack; but with successive years it is apt to recur, either as dysentery or as chronic diarrhœa. Many of the cases are now known to be due to the *amœba coli*. The British Admiralty, on the theory that the mortality of the colonial troops from this cause is in direct ratio to the period of their stay in the tropics, removes and replaces such garrisons at short intervals, while the French Government sends annually to her colonies transports to carry away those soldiers who have become enfeebled by relapses and recurrences of dysentery. A certain number of individuals can never become acclimated to this disease, and find relief only by a return to temperate climes

Another obstacle sometimes fatal to acclimatization, but of rarer occurrence, is hepatitis. This may be either primary, due to heat or malarial infection—in the latter case the enlargement of the liver being analogous to the accompanying splenitis; or the hepatitis may be secondary to dysentery, in which case abscess of the liver may result, usually with a fatal ending These hepatic abscesses are said to be more common in Europeans than in Creoles after a dysentery Other liver diseases, cancers, hydatids, and icterus, due to affections of the gall bladder and ducts, are said by Dr. Saint-Vel, in his work, "Hygiène des Européens dans les Climats Tropicaux," etc., to be rarer in the torrid than in the temperate zone, in spite of the common belief to the contrary.

A degree of anæmia may be considered physiological in hot countries. But it not unfrequently becomes excessive, interfering with the nutrition of the body and combining with a certain amount of malarial poisoning, and perhaps also of hepatitis, to impart the doughy, pale, and sallowish tint not uncommon in those who have lived long in the tropics. This anæmia, sometimes amounting quite to a cachexia, is most extreme in the immediate neighborhood of the equator, growing less with every degree of latitude, and is by no means confined to the white race, though it is only as it occurs to Europeans seeking acclimatization that it deserves mention in this connection.

Intermittent and remittent fevers, now known to be due to the various species of malarial organism, and other manifestations of malarial cachexia are the obstacles which most commonly stand permanently in the way of acclimatization. Recent observations have shown that malaria exists, at least in the northern hemisphere, nearly as far up as the Arctic circle, and the deadly nature of the Tuscan Maremma (lat. 43°) has even given a name to the disease. Still, the most virulent types of the disease are of tropical origin. An individual may resist these influences for a time, to fall a victim without any apparent change either in his own carefulness or in the nature of the surrounding miasmatic influences. Malaria is not confined, like yellow fever, to the coast regions, but is distributed widely. High altitudes are not exempt from it, and it was found by Curran even on the chain of the Himalayas. Still, it is more common in lower levels where vegetation once covered with moisture is left, by a subsidence of the water, exposed to the atmosphere. There are some regions, as, for instance, parts of Senegal, Madagascar, and French Guiana, where the malarial influence is so strong that, while individuals have overcome it, it may be said that, as a race, Europeans hitherto have failed to become acclimated.

In passing from the tropics to the temperate zone, the obstacles in the way of acclimatization are much less than when the emigration is in the other direction. The transi-

tion of seasons from the heat of summer to the cold of winter has a tonic effect, and is favorable to those suffering from anæmia, hepatitis, and malaria. Certain inflammatory chest affections, however, are liable to be caused in Creoles by a northern winter, as well as some cutaneous diseases dependent perhaps on the change in the amount of perspiration. It is often claimed that persons removing to the temperate zone are in special danger from phthisis. Dr. Saint-Vel (*loc. cit.*) says that the reverse of this is true. Some negroes die of tuberculosis in the hospitals, but there are usually circumstances of special exposure in these cases, while those negroes who are well cared for and live at service are remarkably free from phthisis. Confusion has perhaps been made of the negro with the monkey in this respect, but the tuberculosis so common in the latter animal is due to his confinement and to other conditions not obtaining in the case of the negro. The experience of all the Northern States of our country shows that the negro acclimates well in the temperate zone; but observations are wanting as to his power of adapting himself to really cold climates.

The Creoles residing in France are particularly long-lived. Their acclimatization is said to be more readily accomplished than that of whites returning after a long residence in the tropics; but, as a whole, the effect of removal from lower to higher latitudes is more beneficial than that of moving in the contrary direction. Arctic animals do less well in temperate regions than those from the tropics.

Hygiene of Acclimatization.—Hygiene can do something to overcome the obstacles in the way of acclimatization. It is especially important in combating dysentery, anæmia, and malaria. Contrary to what has been sometimes taught, a robust frame is an assistance to acclimatization. The immigrant to the tropics should, if possible, reach his destination in the cool season, that the transition may be as moderate as possible from his native clime. For the same reason the tropical emigrant should reach the temperate zone in the summer. In going to the tropics one should not deprive himself wholly of a meat diet, though of course less meat and very little fat are required. The food should be sufficient in all its constituents to keep up the strength. Alcoholic excess is to be especially avoided. The light wines are much preferable to spirits. A slight diarrhœa is to be checked at once, as otherwise it may run on to the severe chronic intestinal fluxes. The dwelling should be situated high, with the sleeping-room on the second floor. Alluvial bottoms are to be avoided as places of abode, and the domicile should not be erected in the track of breezes blowing over marshy districts. Exposure to the night air is unwise, especially when there is a fog hanging about. Food should be taken before going out in the morning, and a daily dose of quinine should be made use of.

Reference should be made to the probably important part played by certain insects, notably the mosquito, in the communication to man of malaria and possibly of other diseases that have given to some tropical regions an unsavory reputation for deadliness to Europeans. If the teachings of Koch and other believers in the mosquito inoculation of the malarial parasite be confirmed, the employment of nets and bars will assume an important part in the hygiene of acclimatization.

Direct exposure to the equatorial sun during the middle of the day should be avoided. Only the natives can withstand its fierceness. On the other hand, draughts, especially of night wind, should be as carefully avoided as in temperate climes. While the clothing should of course be light, it should be of cotton rather than linen, and merino undergarments should be worn, and changed frequently in order to keep the large amount of transuded moisture absorbed. Nostalgia, which retards acclimatization, should be avoided as far as possible. If society is wanting, work must be relied upon to take up the mind. It is said that the workers acclimatize more readily than the idlers in hot countries. Of the various forms of exercise, which is always so important from a hygienic point of view, riding and driving are especially desirable in warm countries. Cool and cold baths daily are of use. The advantages of hydrotherapy are often combined with those of high elevation in the sanatoria which are located in the mountainous districts (where such exist) in many warm countries, and whither the half-acclimated European repairs from time to time with much benefit to paludic, dysenteric, and hepatic affections. Finally, if dysentery obstinately recurs in the high altitude, or if the system does not throw off miasmatic impressions, it is better, after a reasonable time, to abandon the attempt at acclimatization and return to a temperate climate. The ocean voyage will be likely to cause some relief, and after a reconstitution of the bodily powers in the home country, a second attempt at acclimatization may be more successful. *Charles F. Withington.*

ACCOMMODATION AND REFRACTION. See *Eye, Dioptrics of.*

ACCOMMODATION AND REFRACTION, DISORDERS OF.—ACCOMMODATION is the name adopted to designate the adjustive power of the eye for distinct vision at different distances. As used in modern ophthalmology, it may be more narrowly defined as the power of active optical adjustment of the eye for near vision. In the case of the normally proportioned (emmetropic) eye, the eye, in a state of rest, is adapted for distinct vision at a distance, the accommodation coming into play to increase the optical power (refraction) of the eye to meet the requirements of distinct vision at shorter distances.

The existence of an active accommodative adjustment, effected through an increase in the convexity of the crystalline lens, was demonstrated by Thomas Young (Philosophical Transactions, 1801), but the validity of his proofs was not generally recognized until fully half a century later. The first actual observation of the change in curvature at the anterior surface of the crystalline lens, by Maximilian Langenbeck (1849), was confirmed (1853) by A. Cramer, who, by the employment of more refined methods, measured both the increase in curvature and the position of the anterior lens surface. This was followed closely in time by the wholly independent and altogether admirable research of H. Helmholtz (1855), which definitively established the fundamental theory of accommodation on an exact mathematical basis. Tscherning, who has lately taken up the subject anew, (1894, 1895), has brought to light important additional details.

The changes in the eye in accommodation consist in (*a*) a notable increase of convexity in a central area of the anterior surface of the crystalline lens, (*b*) a much smaller but positively demonstrated increase of convexity in a central area of the posterior surface of the crystalline lens, and (*c*) a slight displacement forward (*i.e.*, in a direction toward the posterior surface of the cornea) of the anterior lens surface; the position of the centre of the posterior lens surface remaining unchanged.

Accommodation is accompanied by active contraction of the pupil, the effect of which is to stop off all but a comparatively small central portion of the crystalline lens, thus excluding the peripheral portions of the lens from participation in the formation of the retinal image. Both accommodation and the accompanying pupillary contraction are essentially binocular acts, and they are sensibly equal in the two eyes. They are, moreover associated with convergence of the visual axes upon the object for which both eyes are accommodated, thus making it possible to see near objects single, as well as distinctly, with the two eyes.

These several adjustments, which go to make up the complex act of binocular accommodation, are co-ordinated under the control of the third (common motor) pair of cranial nerves. Thus the impulse to accommodate, in order to see a small near object distinctly, evokes not only the needful lenticular and pupillary changes in both eyes, but also the simultaneous action of both recti interni

muscles, resulting in convergence corresponding to the distance of the object. Similarly, the impulse to converge the visual axes, in order to make the two retinal images fall each at the central fovea in its own eye and so to prevent the confusion incident to double vision, evokes a simultaneous and equivalent accommodative change, with contraction of the pupil, in both eyes.

The physiological bond by which accommodation and convergence are co-ordinated is, however, elastic, within certain limits. Thus the relation of the two adjustments may be altered, for the time being, by looking through concave or convex glasses, or through divergent or convergent prisms, so as, with unchanged convergence, to force or to relax the accommodation, or, with unchanged accommodation, to increase or to diminish the convergence. Such experiments are, however, fatiguing, and cannot, as a rule, be long continued without giving rise to a vivid sense of discomfort and of functional disturbance.

Again, the relation of accommodation to convergence is progressively changing, from youth to old age, in connection with the physiological increase in the hardness of the crystalline lens, which nevertheless first makes itself seriously felt after middle life as an accommodative insufficiency under the familiar aspect of *presbyopia* or old sight, in which reading becomes difficult or impossible at the ordinary distance of holding the book.

Again, there are many persons, subjects of anomalies of the eyes which involve notable variations in the relation of accommodation to convergence, who nevertheless experience no difficulty in the habitual free use of the eyes in near work, or perhaps even imagine that they enjoy exceptionally good vision. These are, however, generally cases of a congenital anomaly, or else of one which is of gradual development, giving time for a correspondingly gradual change in the relation of the two adjustments one to the other.

The accommodative power which the eye can bring into exercise is called the *range of accommodation*; it is conveniently measured in units called dioptries, one dioptrie (1 D) being equivalent to a convex lens of 1 metre focal length.

The maximum range of accommodation for any eye is attained when the fellow eye is covered, or otherwise excluded from participation in the visual act, and is free to assume a position of extreme convergence. This maximum range is called the *absolute range of accommodation*. The range of accommodation for the two eyes together, under convergence for any particular distance, is called the *relative range of accommodation*.

The relative range of accommodation varies greatly for different distances. Thus Donders (1858) found that in a young person, of the age of fifteen years, it was possible to accommodate with either eye singly up to a distance of 3.69 Paris inches (about 10 cm. = $\frac{1}{10}$ metre), indicating an absolute range of accommodation of about 10 D. With the two eyes together, it was possible to see distant objects distinctly through concave glasses of any power up to a limit of 11 Paris inches (negative) focal length (about 29.7 cm. = $\frac{1}{3.37}$ metre), indicating a relative range of accommodation of about 3.37 D under parallelism of the visual axes. Under convergence for a distance of 3.9 Paris inches (about 10.5 cm. = $\frac{1}{9.5}$ metre) it was just possible to accommodate for that distance, but it was also possible to see distinctly, with the two eyes, through convex glasses of any power up to a limit of 9 Paris inches (about 24.3 cm. = $\frac{1}{4.1}$ metre) focal length, indicating a negative relative range of accommodation of about −4.1 D. Under higher grades of convergence, *i.e.*, for distances less than 3.9 Paris inches (10.5 cm.), it was impossible to accommodate, with the two eyes, for the distance of the point of intersection of the visual axes; in other words, distinct binocular vision was possible only at distances greater than about 10.5 cm. ($\frac{1}{9.5}$ metre), indicating a *binocular range of accommodation* of about 9.5 D. Under convergence for all distances greater than 3.9 Paris inches, it was found that the two eyes could accommodate for a distance less than that of the intersection of the visual axes, and also for a greater distance; in other words, the relative range of accommodation was in part positive and in part negative. "This distinction acquires practical importance from the fact *that the accommodation can be maintained only for a distance at which, in reference to the negative, the positive part of the relative range of accommodation is tolerably great.*"—Donders.

Fig. 10 shows, in the form of a diagram, the series of measurements of the relative accommodation in the case cited, as plotted by Donders; the ordinates indicate dioptries of accommodation, and the abscissas the corresponding degrees of convergence, namely, for distances of 1 metre and aliquot parts ($\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, to $\frac{1}{20}$) of a metre.*

By inspection of the diagram it is seen that the positive part of the relative range of accommodation—*i.e.*, the part above the diagonal line KK′—appears only in convergence for distances greater than about 10.5 cm. ($\frac{1}{9.5}$ metre); at 12.5 cm. ($\frac{1}{8}$ metre) the positive part is about three-sevenths as great as the negative; at 33.3 cm.

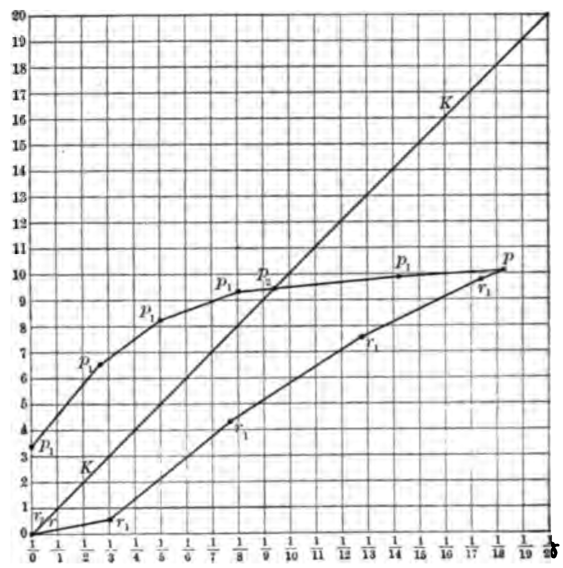


FIG. 10.

($\frac{1}{3}$ metre) the positive part exceeds the negative in the ratio of about 8 to 5.

These relations of the positive to the negative part of the relative range of accommodation correspond closely to actual conditions as learned from every-day observation of the working of the accommodation in young persons. Thus a child of say 12 years can ordinarily force his accommodation so as to see minute objects distinctly for a short time at a minimum distance of about 10 cm., using about 10 D of accommodation. At a little greater distance, about 12.5 cm., using about 8 D of accommodation, he can read for a much longer time, although not, as a rule, without a consciousness of effort leading to fatigue. At about 20 cm., using about 5 D of accommodation, the accommodation can often be maintained for hours together in close work, but not without incurring the risk of ultimate grave injury to the eyes when reading at so short a distance becomes habitual. The limit of ease and safety, for young persons, in long-continued use of the eyes in reading and study, is at about 33 cm. (about 13 English inches), or perhaps a little less, corresponding to an habitual use of not much more than 3 D of accommodation. At this limit of distance the relative range of accommodation is ample, and the positive part is at about its maximum.

* Fig. 10 has been slightly changed to conform to the metric system, which has come into general use in ophthalmology since the date of publication of Donders' work.

The letters r, r_1, r_2, and p, p_1, p_2 (Fig. 10) represent the *absolute*, the *relative*, and the *binocular* farthest and nearest points, respectively, of distinct vision. Under parallelism of the visual axes the absolute far point (r), the relative far point (r_1), and the binocular far point (r_2) all fall together at an infinite distance; but there is a positive relative accommodation of about 3.37 D. Under convergence for a distance of 10.5 cm. ($\frac{1}{9.5}$ metre), the relative near point (p_1) and the binocular near point (p_2) fall together at the same distance of about 10.5 cm. from the eye; but there is a negative relative accommodation, which here attains its maximum, of −4.1 D. The absolute near point (p) is attained only under extreme convergence (for a distance of about 5.5 cm. $= \frac{1}{18}$ metre), and falls, together with the relative near point (p_1), at about 10 cm. ($\frac{1}{10}$ metre) from the eye; under this maximum exertion the relative range of accommodation is reduced to zero. Under convergence for all distances greater than 20 cm. ($\frac{1}{5}$ metre), the positive part of the relative range of accommodation is large and nearly constant, falling nowhere below about 3.25 D, and reaching a maximum of nearly 4 D at a distance of about 38 cm.

TABLE A.

Accommodation in dioptries.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Distances in metres.	∞	$\frac{1}{1}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{10}$	$\frac{1}{11}$	$\frac{1}{12}$	$\frac{1}{13}$	$\frac{1}{14}$	$\frac{1}{15}$	$\frac{1}{16}$	$\frac{1}{17}$	$\frac{1}{18}$	$\frac{1}{19}$	$\frac{1}{20}$

Table A represents, in parallel series, consecutive dioptrics of accommodation and the corresponding distances at which a normally proportioned (emmetropic) eye sees distinctly through the exercise of the accommodation. It will be observed that the first dioptrie of accommodation covers all distances from infinity up to a distance of 1 metre from the eye; the second covers a distance, $1 - \frac{1}{2} = \frac{1}{2}$ metre; the third, $\frac{1}{2} - \frac{1}{3} = \frac{1}{6}$ metre; the fourth, $\frac{1}{3} - \frac{1}{4} = \frac{1}{12}$ metre; the tenth, $\frac{1}{9} - \frac{1}{10} = \frac{1}{90}$ metre; the twentieth, $\frac{1}{19} - \frac{1}{20} = \frac{1}{380}$ metre, etc.

Inasmuch as the distance of the near point (p) from the eye is the reciprocal of the number of dioptries of accommodation, it follows that when the effective range of accommodation exceeds 1 D the distance of p from the eye will be represented by some fractional part of 1 metre. Again, if, for any cause, the far point (r) falls at a distance (which we will represent by R) less than 1 metre from the eye, the distance of the near point (p) from the eye (which we will represent by P) will be less than when r is at infinity, but will still always have a real value represented by some fraction of 1 metre. The linear distance R—P, covered by any given range of accommodation, decreases, therefore, at a rapidly increasing rate for every change in the position of r nearer to the eye. The linear distance, R—P, is called the *region of accommodation;* its special significance will appear more fully in connection with the study of the Anomalies of Refraction, and of the changes effected by wearing spectacles.

REFRACTION is the word used in ophthalmology to designate the optical power of the eye when in a state of accommodative relaxation or rest. It is, in fact, the aggregate of successive refractions, (*a*) from the air into the cornea, (*b*) from the cornea into the aqueous humor, (*c*) from the aqueous humor into the crystalline lens, (*d*) from layer to layer of the crystalline lens, through a medium of progressively increasing refractive power (index of refraction) from its anterior surface toward its centre, and of decreasing refractive power from its centre to its posterior surface, and (*e*) from the crystalline lens into the vitreous body. Inasmuch as the curvatures of the several refracting surfaces and the indices of refraction of the several transparent media remain constant or nearly constant, after the eye has once attained to its full development, the absolute refraction, as determining the position of the principal focus, is practically a constant quantity for any particular eye.

The principal posterior focal length (focal length for parallel rays) of the human eye, measured from its second (posterior) principal point, is estimated at about 20 mm. ($\frac{1}{50}$ metre). To represent the sum of the several refractions in the eye by one refraction, at a single spherical surface, we have only to assume an infinitely thin cornea of 5 mm. radius of curvature and, suppressing the crystalline lens, to assume a length for the axis of the eyeball equal to 20 mm.* This simplified or *reduced* eye, again, may be represented by a thin convex lens of 66.6 D power, mounted 15 mm. ($\frac{1}{66.6}$ metre) in front of a screen representing the retina.

The measurements of the radii of curvature of the cornea and of the two surfaces of the crystalline lens are, however, found to vary notably in different eyes, and this without giving rise to any corresponding anomaly in the functions of the eye as a whole. The explanation is found in other, compensating variations in the size (length of axis) of the eyeball. Thus a very small eyeball, with correspondingly short radii of curvature of its refracting surfaces, *e.g.*, the eye of a mouse, may be as perfectly proportioned as a much larger eyeball, with correspondingly greater radii of curvature, *e.g.*, the eye of a rabbit. Estimates of the actual refraction, even in the case of the human eye, are therefore at best but average estimates; they are, moreover, of minor importance, and are practically disregarded in the discussion of ophthalmological problems. On the other hand, any deviation from a correct proportion between the curvatures of the refracting surfaces and the length of the axis of the eyeball is of very great importance, for it is upon such correct proportion that the adaptability of the eye to the varied requirements of vision mainly depends.

We have then to recognize, first of all, a normal condition of correct proportion, *emmetropia*, E (from ἔμμετρος, proportionate, and ὤψ, eye), between the radii of curvature of the refracting surfaces of the eye and the length of the antero-posterior diameter (axis) of the eyeball. In emmetropia, a sharply defined image of a distant object is formed on the retina without the exercise of any part of the accommodation, so that the entire range of accommodation is available to meet the requirements of distinct vision for near objects. The region of accommodation includes, therefore, all distances from infinity up to the distance of the near point (p) from the eye, and is at its maximum (*cf.* Table A).

As opposed to emmetropia we recognize a condition of incorrect proportion, *ametropia* (from ἄμετρος, disproportionate, and ὤψ, eye), in which the principal focus of the eye falls elsewhere than at the distance of the retina. Ametropia occurs under two opposite types, according as the retina lies in front of or behind the principal focus.

Hypermetropia, H (from ὑπέρμετρος, over-measure, and ὤψ, eye), is the condition in which the principal focal length of the eye is greater than the length of its axis. The hypermetrope, if his range of accommodation is in excess of that required to advance the focus for parallel rays to the actual position of the retina, is able, through the exercise of some part of his accommodation, to see clearly at a distance. A part only of the range of accommodation is then available for near vision, and, through the recession of the near point, the region of accommodation is curtailed. In the highest grades of hypermetropia the range of accommodation is insufficient to overcome the refractive defect, so that distant as well as near objects are seen indistinctly; in the lower grades the recession is often not so great as to interfere materially with distinct near vision, so long as the range of accommodation remains normal or approximately normal. The accommodation is nevertheless overburdened in hypermetropia, and its exercise is often attended with a sense of strain or fatigue; with advancing age, the recession of the near point, due to the progressive diminution of the range of accommodation, gives rise prematurely to the condition of old sight (*presbyopia*).

In hypermetropia the disproportion is ordinarily due to an actual deficiency in the length of the antero-posterior

* The index of refraction from air into the aqueous humor is assumed to be $\frac{4}{3}$ = 1.3, which, though not absolutely exact, is a very close approximation to the true index.

diameter of the eyeball, and may properly be regarded as the result of incomplete development of the eye in its posterior segment. The crucial test of hypermetropia is the ability to see distinctly at a distance through convex glasses; its measure, in dioptries, is the strongest convex lens through which vision at a distance is unimpaired. (See *Hypermetropia.*)

Myopia, M (from μυώψ, winking or shutting the eye), is a condition the exact opposite of hypermetropia. As a visual defect, myopia was well known to the Greek and Roman writers on scientific subjects; it takes its name from the fact that short-sighted persons see distant objects more clearly when the opening of the eyelids is reduced to a narrow slit. In myopia the principal focal length of the eye is less than the length of its axis. The myope, therefore, even under complete relaxation of his accommodation, does not see distinctly at a distance; but he has perfect vision, without exercise of the accommodation, at some short distance defined by the position of his far point (r), which position is determined by the grade of myopia. The near point (p) of distinct vision, as determined by the range of accommodation and measured from r, falls nearer, therefore, to the eye than in emmetropia. The region of accommodation, *i.e.*, the difference in distance of the far point and the near point from the eye, is notably restricted, and in the highest grades of myopia is reduced to insignificance. In myopia of low grades, the disability of old sight (*presbyopia*) is first experienced at a later period of life than in emmetropia; in the higher grades of myopia, in which the far point (r) lies well within the ordinary reading distance, presbyopia, in the ordinary acceptation of the word, is an impossibility.

In myopia the disproportion is due to an elongation of the axis of the eye incident to distention of the eyeball, as a result, in most cases, of improper or excessive application to close work during the period of childhood and youth. Unlike hypermetropia, myopia is to be regarded as essentially a pathological condition; and it is generally progressive, increasing in grade from year to year provided that the active causes continue operative. The test of myopia is the inability to see distant objects distinctly except through concave glasses; its measure, in dioptries, is the weakest concave lens which brings distant vision up to the same standard of acuteness as at distances within that of the far point. (See *Myopia.*)

The positions of the far point (r) and of the near point (p), respectively, are measured, in metres and parts of a metre, from the anterior nodal point of the eye, which is situated in the crystalline lens about 0.25 mm. from its posterior surface. Representing these distances by R and P, respectively, the range of accommodation, expressed in dioptries, by A, and the degree of myopia or of hypermetropia, expressed also in dioptries, by M or H, respectively, we have:

In *emmetropia*, $R = \text{infinity}$,

$$P = \frac{1}{A}\text{ metre};$$

in *myopia*, $R = \frac{1}{M}$ metre,

$$P = \frac{1}{A + M}\text{ metre};$$

in *hypermetropia*, $R = -\frac{1}{H}$ metre,

$$P = \frac{1}{A - H}\text{ metre}.$$

As, however, the actual limit for distant vision is at infinity, this must represent the position of the far point (r) in hypermetropia; the expression of the real condition then becomes:

In *hypermetropia*, $R = \text{infinity}$,

$$P = \frac{1}{A - H}\text{ metre}.$$

From a comparison of these equations it will be seen how, with the same range of accommodation, the region of accommodation is most extensive in emmetropia. In myopia the region of accommodation is greatly contracted through the approach of the far point (r), with but slight and, in the higher grades of myopia, unimportant compensation in the approach of the near point (p) to the eye. In hypermetropia the effective range of accommodation is diminished, and the region of accommodation is curtailed through the recession of the near point (p) from the eye, the far point (r) remaining, as in emmetropia, at infinity. When H is so large, or A so small, that A is less than H, the entire range of accommodation becomes negative, and distinct vision is impossible at any distance.

By the correction of the ametropia, by an appropriate concave or convex glass, the far point (r) is adjusted to infinity, and the position of the near point (p) is then determined by the range of accommodation (A). The equations for myopia and for hypermetropia then become identical with that of emmetropia.

In *myopia*, $R = \frac{1}{M - M} = \frac{1}{0} = \text{infinity}$,

$$P = \frac{1}{A + M - M} = \frac{1}{A}\text{ metre};$$

in *hypermetropia*, $R = \frac{1}{H - H} = \frac{1}{0} = \text{infinity}$,

$$P = \frac{1}{A - H + H} = \frac{1}{A}\text{ metre}.$$

We have thus far considered only the case of ametropia in a single eye, and have ignored all complications growing out of the fact that vision is actually the result of the concurrent action of the two eyes. In brief, it may be said that in order to see an object single and distinctly with the two eyes together, the eyes must be accurately directed each to the same point, and this point must be a point for whose distance each eye is accommodated. The close connection between accommodation and convergence may lead to important complications both in myopia and in hypermetropia. In myopia, there is comparatively little occasion for the exercise of the accommodation, but the need for convergence remains unchanged, or may even be increased by reason of the shorter distance at which the strongly myopic eye sees small objects. This, normal or excessive, convergence may in turn evoke accommodation for a still shorter distance, and so necessitate the holding of the book still nearer to the eyes, thereby inciting again to stronger convergence. The excessive accommodation which is thus excited may cause the myopic eye to appear more strongly myopic than it really is, and may lead, through long-continued tension of accommodation, to pathological conditions resulting in progressive increase in the grade of the myopia. On the other hand, the eyes may fall into the habit of relaxing the accommodation to the degree requisite for distinct vision at or near the far point, in which case the attendant relaxation of the convergence may lead to relative insufficiency of the recti interni muscles, with resultant muscular fatigue from the effort to maintain binocular vision (muscular asthenopia); or else the effort to maintain binocular vision may be abandoned, and a condition of actual muscular insufficiency (divergent strabismus) established. In hypermetropia the eyes accommodate even in distant vision, and must accommodate more strongly than in emmetropia in order to see near objects distinctly. Accordingly, in hypermetropia one of two complications may arise: either the convergence may be habitually adjusted to the distance of the object, in which case the correlated accommodation may be insufficient for continuous near work, and so the eyes may suffer from accommodative insufficiency or fatigue (*accommodative asthenopia*); or, on the other hand, the accommodation may be maintained to the degree requisite for distinct vision, and this excessive accommodative effort may evoke a tendency to excessive

convergence, which may develop into convergent strabismus. (See *Asthenopia*, *Strabismus*.)

The effect of the disturbed correlation between accommodation and convergence in ametropia has been concisely formulated by Donders, as follows:

Hypermetropia causes accommodative asthenopia, to be actively overcome by strabismus convergens.

Myopia leads to muscular asthenopia, passively yielding to strabismus divergens.

Astigmatism is a refractive anomaly in which the refractive power of the eye is unequal in different meridians. (See *Astigmatism*.) This inequality is greatest in two meridians which lie at right angles to each other, and which are called the principal meridians. The astigmatic eye may be emmetropic in one of its principal meridians, in which case it is either myopic or hypermetropic in the other; or it may be either myopic or hypermetropic in both meridians; or, lastly, it may be myopic in one of its principal meridians and hypermetropic in the other. If the astigmatic eye is hypermetropic in its horizontal meridian, the accommodative disturbances generally simulate those which belong to hypermetropia, namely, accommodative asthenopia, or a tendency to convergent strabismus; if, on the other hand, the eye is myopic in its horizontal meridian, the complications are more commonly those which belong to myopia, namely, muscular asthenopia or insufficiency. Moreover, as in astigmatism the acuteness of vision is more or less inpaired, the inclination is always to hold the book too near to the eyes, and thus the tendency to accommodative tension or to muscular insufficiency, on the one hand, or to muscular tension, or to accommodative insufficiency, on the other hand, is materially increased.

Irregular astigmatism (see *Astigmatism*) necessarily impairs the acuteness of vision at all distances, and may prove a source of disability or of danger through the forcing of both accommodation and convergence in the effort to read continuously at a very short distance.

The correction of regular astigmatism, together with any accompanying ametropia, by means of appropriate cylindrical, spherico-cylindrical, or toric, lenses, both improves the acuteness of vision and removes the disabilities incident to the displacement of the region of accommodation. Even in irregular astigmatism a part of the refractive defect may often be corrected by means of some form of cylindrical lens, with corresponding improvement in the acuteness of vision.

Unequal refraction in the two eyes—*anisometropia* (from ἄνισος, unequal, μέτρον, measure, and ὤψ, eye)—may give rise to certain complications growing out of the close connection between accommodation and convergence. Moreover, as the accommodation is sensibly equal in the two eyes, the same degree of inequality exists in accommodation as in a state of rest, so that the two eyes are never accurately accommodated for the same distance at the same time. In order to see any object clearly, one of the eyes must therefore accommodate accurately for its distance, while the other eye is accommodated for some other distance. Hence one of the retinal images is distinct, while the other is imperfectly defined. This difference in definition is, however, not of very great importance, for, practically, the attention is concentrated upon the clearer image, and the confused details of the other image are disregarded. Both images are, however, utilized in binocular vision, as is shown by the persistence of the binocular faculty of estimating differences of distance and of appreciating the form of solid objects (stereoscopic vision). On theoretical grounds a certain improvement in the acuteness of vision should result from the accurate correction of both eyes by means of glasses of different foci, and this is actually the fact in the case of lesser differences in refraction, but in cases of great difference, equalizing glasses are not always readily accepted. A person with one emmetropic eye of normal visual acuteness will not ordinarily accept glasses for the sole purpose of remedying a defect of which he is perhaps unconscious and which causes him no inconvenience; and, similarly, many persons with ametropia of a different grade in the two eyes will rest satisfied with glasses of equal foci, which leave the existing refractive difference unchanged. Hence it is, as a general rule, unnecessary to give glasses for an uncomplicated refractive error of one eye, and, in cases of unequal defect in the two eyes, it is often sufficient to prescribe glasses of equal foci, selected with reference to the condition of the eye which is habitually in use.

The complications which may make it necessary to prescribe glasses of different foci in anisometropia occur chiefly in cases of myopia of one eye, or of myopia of a different grade in the two eyes. In myopia of one eye, with emmetropia or moderate hypermetropia of the other,* the myopic eye is ordinarily used in reading, and the emmetropic or hypermetropic eye in distant vision. Such a person may suffer from muscular asthenopia or insufficiency of the recti interni, as a consequence of the habitual relaxation of the accommodation in reading, or from injurious tension of the accommodation, with a tendency to progressive increase of the grade of myopia, incident to the habit of converging accurately for the reading distance. In such cases it is generally best to correct the myopic eye by means of a suitable concave glass, and to prescribe for the other eye either a plane glass or a convex glass suited to the grade of its hypermetropia. In myopia of a different grade in the two eyes it is the rule to correct the less myopic eye for distance, and to give either the same glass, or one of shorter focus, to the more myopic eye, as may be found most satisfactory upon trial. If the difference in the refraction of the two eyes is large (two dioptries or more), a partial correction of the more myopic eye may be preferred in the beginning, and the full correction may be accepted after the lapse of a few weeks or months.

Aphakia (from α, privative, and φακός = *lens*, a lentil) is the condition in which the crystalline lens is either wholly wanting or is so displaced that it no longer lies in the axis of the eyeball. The focal length of the crystalline lens, within the eye, is estimated at 43.7 mm., representing a refractive power of about 23 D. The aphakial eye has therefore sustained a loss of refractive power equal to about 23 dioptries, besides the loss of its entire accommodation. In correcting aphakia by means of a convex glass, the position of the glass (about half an inch in front of the cornea) is much more advantageous than that of the crystalline lens which it replaces, so that a glass of ten or eleven dioptries is sufficient, in most cases, to make good the refractive deficiency. The retinal image is also enlarged by about one-third, in consequence of the change in the position of the nodal point. A certain degree of accommodative adjustment, with additional enlargement of the retinal image, may be obtained by holding the glass farther from the eye, but as the distance at which the glass can be easily held is limited to the length of the nose, it is too small to admit of the necessary adjustment for reading. Hence two glasses are generally required, a weaker glass, of ten or eleven dioptries, for distant vision, and a stronger glass, of say thirteen to fifteen dioptries, for reading. If the aphakial eye is of hypermetropic construction, proportionally stronger glasses, and if of myopic construction, proportionally weaker glasses, are required. In aphakia of one eye, with normal visual acuteness of the other eye, it is impossible, by any glass, to make the retinal images equal in size in the two eyes, yet even with this drawback the correction of the aphakial eye is generally accepted by young persons, with the very great advantage of helping to keep the eye in use, and so opposing the not infrequent tendency to drift into a position of divergent (or more rarely of convergent) strabismus. An aphakial eye, even when uncorrected, generally takes some part in binocular vision, and is of use by enlarging the general field of vision, and also by assisting in the estimation of distances. A considerable grade of astigmatism is frequently present in aphakia, which may be due either to original asym-

* The name *antimetropia* has been proposed for the particular form of anisometropia in which one eye is hypermetropic and the other myopic.

metry of the cornea or to an acquired asymmetry incident to the healing of a corneal wound or of the incision in the operation for the extraction of cataract. Low grades of astigmatism are often overcome by looking obliquely through the strong convex glasses worn to correct the aphakial condition; higher grades may require correction by a spherico-cylindrical or toric lens. (See *Astigmatism*.)

Disorders of accommodation may occur as a result either of an abnormal condition of the special organ of accommodation, the crystalline lens, or of disordered innervation.

The progressive hardening of the crystalline lens, which has already begun in youth, and which goes on probably throughout the entire duration of life, becomes, after middle life, an insurmountable obstacle to such change in the form of the lens as is essential to perfect accommodation for the usual reading distance. (See *Presbyopia*.) Only in myopia is there an apparent exception to this statement, owing to the fact that the far point (r) often lies so near to the eye as to bring it within the ordinary reading distance of 30 cm. (12 inches). In such cases the myope never becomes presbyopic in the sense of being unable to read without the aid of convex glasses; but whereas in youth he reads easily with the concave glasses which accurately correct his myopia, he is compelled, with advancing age, either to lay aside his glasses in reading or to exchange them for weaker concave glasses than those through which he sees well at a distance. In hypermetropia, on the other hand, the loss of accommodation shows itself by an early recession of the near point (p), so that help is sought from convex glasses, perhaps long before the usual age of from forty to forty-five years. The young hypermetrope, wearing convex glasses which correct his hypermetropia, is able both to see at a distance and to read, and it is only at the age of about forty-five years that he finds himself compelled to exchange these glasses for stronger reading glasses. Under no circumstances can a presbyope see clearly at a distance and read easily with the same glasses. Either he is an emmetrope, in which case he requires convex glasses for reading, but none for distant vision; or he is a myope, and so requires concave glasses for distance, and weaker concave glasses, or no glasses at all, or possibly even weak convex glasses, for reading; or he is a hypermetrope, and so sees distinctly at a distance with neutralizing convex glasses, but requires stronger convex glasses for reading.

Paralysis or paresis of accommodation from defective innervation may be the result of an affection implicating the terminal branches of the ciliary nerves, or any part of the nervous tract between these and the central origins of the oculomotor nerve in the ganglia and cortex of the brain. It is accompanied by dilatation and loss of mobility of the pupil, and in many cases also by paralysis or paresis of one or more of the muscles supplied by the oculomotor nerve, namely, the levator palpebræ superioris, the rectus superior, the rectus inferior, the rectus internus, and the obliquus inferior.

A typical example of paralysis of accommodation dependent on impairment of the function of the terminal branches of the ciliary nerves is that which follows the instillation of a mydriatic solution into the conjunctival sac. Within fifteen minutes after the instillation of a drop of a solution of atropia sulphate of a strength of one per cent. (1:100), the pupil begins to dilate, and within half an hour the dilatation reaches its maximum, and the pupil no longer contracts under the stimulus of strong light. Closely following the dilatation of the pupil, the near point (p) begins to recede rapidly from the eye, and the paralysis of accommodation is complete at the end of about an hour and a half. The dilatation of the pupil and the paralysis of accommodation continue without sensible change for about two days, after which both begin to pass away, the former very gradually, the latter more rapidly for two or three days and afterward more slowly, until at the end of ten or twelve days the effect of the drug disappears altogether. The effect of very weak solutions of atropia, say of a strength of one one-hundredth of one per cent. (1:10,000), is to dilate the pupil in the course of an hour and a half or two hours, but without rendering it immovable under the influence of strong light, and without greatly affecting the accommodation. Under the action of atropia the near point (p) recedes from the eye until it comes to coincide with the far point (r). Hence the visual disturbance varies very conspicuously according to the refractive condition of the eye. In emmetropia distant vision remains clear, but accommodation for the near is rendered impossible; in hypermetropia vision becomes indistinct for the distance, and still more so for the near; while in myopia of a rather high grade there may be no trouble in reading, and the loss of accommodation, within the narrow limit of distance between the far point and the near point, may give rise to little inconvenience or may even pass unnoticed. To the hypermetrope or myope wearing glasses which correct his refractive defect the visual disturbance is the same as in emmetropia. Several other plants, belonging mostly to the natural family *Solanaceæ*, yield alkaloids whose action is nearly identical with that of atropia; cocain also, the active principle of *erythroxylon coca*, has the property of dilating the pupil, with a minimum effect on the accommodation. Euphthalmin hydrochlorate, a synthetic product lately introduced in ophthalmic practice, has mydriatic properties similar to those of cocain.

Concussion of the eyeball is sometimes followed by weakening or loss of the accommodation, conjoined with dilatation of the pupil. This condition may soon pass away, or it may be permanent.

Diphtheria is often followed by paresis of accommodation, with enlargement of the pupils. It occurs, as a rule, after recovery from the throat affection, and has ordinarily a duration of several weeks. It is generally associated with paresis of the palatine muscles, giving rise to characteristic alteration of the speech, and difficulty of swallowing liquids. The external muscles of the eye may also be affected, and cases of true convergent strabismus have been observed as a result of excessive efforts to accommodate in the weakened condition of the accommodation. The symptoms of paresis of accommodation following diphtheria are essentially the same as in asthenopia resulting from the overloading of the accommodation in hypermetropia, and the use of convex glasses is often indicated as an aid in reading during the continuance of the disability; the instillation of a drop of a weak solution of pilocarpine, two or three times a day, is also of utility in many cases.

Pressure upon the ciliary nerves, from intra-orbital hemorrhage, inflammatory exudation, tumor, etc., may give rise to loss of accommodation and dilatation of the pupil, without affecting the function of any of the external muscles of the eyeball.

In lesions affecting the conductivity of the oculomotor nerve, the accommodative disturbance and dilatation of the pupil are accompanied by paralysis of the levator muscle of the upper lid (ptosis), of the recti muscles (excepting the abducens), and of the inferior oblique muscle.

Mydriasis, with loss of accommodation, may occur as a symptom of intracranial disturbance, affecting the central origins of the oculomotor nerve. Such disturbance may be the result of a pathological process (syphilis, embolism, etc.), in which case it is apt to be associated with paralysis of one or more of the external muscles of the eyeball.

Exposure to sudden changes of temperature is sometimes followed by paralysis of one or more of the motor nerves of the eye or of the eyelid. These cases, which are often designated as rheumatic, end frequently in perfect recovery after some days or weeks; in other instances they prove rebellious to all treatment.

The constitutional effect of an overdose of any one of the common mydriatic drugs (belladonna, datura, hyoscyamus, duboisia), administered by the stomach or hypodermically, is marked by conspicuous dilatation of the

pupils, with loss of accommodation. If the patient survives the toxic influence, these symptoms disappear after a short time.

True spasm of accommodation, as distinguished from the condition of accommodative tension already noticed in connection with ametropia, is of comparatively rare occurrence, and is a result of irritation of the ciliary nerves or the oculomotor nerve centres. It is associated with contraction of the pupil, and is the exact opposite of accommodative paralysis with mydriasis. Certain drugs (*myotics*), instilled into the conjunctival sac, have the property of evoking accommodative spasm with contraction of the pupil. A single drop of a solution of eserine sulphate (the active alkaloid of Calabar bean), of the strength of one-half of one per cent. (1:200), brings on contraction of the pupil and spasm of accommodation, which begin nearly simultaneously within about ten minutes, and reach a maximum in from thirty to forty minutes. After about two hours, the far point (r), which at the height of the action of the drug is not over 20 cm. (eight inches) from the eye, is found to have receded to its normal position (infinity in the emmetropic eye); but the near point, in voluntary accommodation, is considerably nearer than normal after the lapse of six hours, showing a temporary increase in the range of accommodation. The contraction of the pupil begins to diminish after about two hours, at first slowly, then more rapidly for about four hours more, and afterward slowly until, at the end of two days, the pupil has nearly or quite regained its normal diameter. With a weaker solution of eserine the spasm of accommodation is much less than with the half-per-cent. solution, and is painless; with the stronger solution the action is accompanied by a sensation of spasmodic jerking, with some pain. Pilocarpine, the active alkaloid of jaborandi, is much milder in its action than eserine, but is nevertheless an efficient myotic, and exerts also a very positive effect in stimulating the accommodation.

Contraction of the pupil is frequently observed in central nervous affections, and notably in tabes dorsalis. Myosis, with spasm of the accommodation, follows also the administration of large doses of eserine, opium, and some other drugs, internally. The internal or hypodermic use of pilocarpine does not produce contraction of the pupil or spasm of accommodation.

Irritation of the fifth cranial nerve (ophthalmic division) is followed by contraction of the pupil, and the same phenomenon may attend irritation of the terminal branches of this nerve in the cornea. Myosis from this cause may also be attended with spasm of accommodation.

John Green.

ACEPHALUS. See *Teratology*.

ACETABULUM, FRACTURES OF, may be divided into compound and subcutaneous, or, as regards their causation, into direct and indirect. The hip joint is so deeply situated and so efficiently protected by the surrounding bony projections and soft tissues against direct violence that fractures produced in this manner almost invariably belong to the compound variety, and in the great majority of cases they are the result of gunshot injuries. Gunshot wounds of the hip joint, with or without fracture of the acetabulum, have always been considered by surgeons as formidable and dangerous lesions. Pirogoff made the statement that during the Crimean War all injuries of this kind proved fatal. During the War of the Rebellion nearly all cases of gunshot injuries of the hip-joint treated on the conservative plan resulted in death. Of 63 cases of similar injury in which resection was performed, only 5 recovered. In his classical treatise on this subject, B. von Langenbeck collected 119 cases which occurred during the Franco-Prussian War, with 29 recoveries; 88 were treated on the expectant plan, with 25 recoveries; 31 were submitted to excision, with 4 recoveries.

The acetabulum may be fractured without injury of the head or neck of the femur, as the bullet may impinge upon the floor of the acetabulum, from within the pelvis, with sufficient force to break the bone, producing a fissure or stellate fracture of its base, or it may, in its course, carry away the rim of the cotyloid cavity. An exceedingly interesting case, illustrating the latter assertion is reported by Dr. J. F. Miner, of Buffalo (*Buffalo Med. and Surg. Journal*, vol. v., p. 383). Lieut.-Col James Strong, of the Thirty-eighth New York Volunteers, was wounded, May 5, 1862, at the battle of Williamsburg, Va. The ball entered a little below the anterior superior spinous process of the ilium, and made its exit near the outer margin of the sacrum. The ball passed deeply, and fractured, in its course, the rim of the acetabulum, which was removed, an inch and a half in length, and of a diameter sufficient to show that the whole upper rim had been carried away. This fragment of bone was removed from the wound at the dressing made in the hospital to which he was carried, after having lain on the field for some hours. The wound was very large, and a thorough examination could be made by the easy passage of the finger. The patient passed through a serious and prolonged illness from the suppuration and hectic fever which followed, but finally recovered, with five inches shortening of the limb, inward rotation of the foot, and bony ankylosis between the dislocated thigh bone and the ilium. The points of entrance and exit of the projectile furnish valuable information in regard to the probable injury of the acetabulum in gunshot fractures of the hip joint. In the case here reported, the ball entered just below the anterior superior spinous process of the ilium, and passed out near the margin of the sacrum, leaving intact the head of the femur, but opening the hip joint by carrying away the superior and posterior margin of the rim, thus permitting the subsequent dorsal dislocation of the head of the femur by muscular force. B. von Langenbeck states that, in case the ball enters directly below and toward the outer side of the spine of the pubes, and takes its exit in the region behind the greater trochanter of the same side, as a rule it penetrates the hip joint; and, at the same time, it fractures in its course the upper rim of the acetabulum. Escape of synovial fluid, swelling in the region of the hip joint from extravasation of blood or the products of inflammation, preternatural motion in the joint, crepitation, and dislocation of the head of the femur spontaneously or on manipulation, are other important diagnostic symptoms. The most important information regarding the exact nature of the injury is, however, obtained by enlarging the track of the bullet and rendering the hip-joint accessible to touch and sight. This procedure, done under antiseptic precautions, not only affords an opportunity to ascertain the true nature and gravity of the injury, but it is imperatively called for as the first and most important step in the treatment. All foreign bodies and detached pieces of bone should be removed, all hemorrhage carefully arrested, and the whole injured surface and surrounding parts thoroughly disinfected; effective drainage should be established, and every possible source of infection guarded against by dressing the wound antiseptically. All these measures are essential, as the success of the operation and the life of the patient depend on procuring and maintaining an aseptic condition of the wound. The leading principle in the treatment should be, from the very beginning, to convert the compound into a simple fracture, and thus protect the patient against the disastrous consequences of traumatic infection, exhausting suppuration, pyæmia, and septicæmia.

Subcutaneous or simple fractures are again divided into those which involve the floor and those which involve the rim of the acetabulum. This division rests on clinical experience as well as on the results of experimental research. Fractures of the base or floor of the acetabulum, notwithstanding their rare occurrence, yet present a great diversity in the direction and extent of the line of fracture. Courant observed a fracture which traversed the ilio-pectineal tubercle, the entire acetabulum, and the ischium. Earle and Travers describe two cases in which two lines of fracture passed through the

acetabulum; Neill and Sansom saw cases with three lines of fracture which extended beyond the rim. In Dr. Neill's specimen the lines of fracture followed those of the embryonal division of the bone; the union which followed was complete, and there was very little callus on the articular surface, a circumstance undoubtedly due to the slight displacement of the fragments. More serious to the life of the patient and the future utility of the limb are those cases in which a multiple fracture at the base exists with such wide separation between the fragments as to allow the head of the femur to be driven into the pelvis by the fracturing force, thereby producing an intrapelvic dislocation of the thigh. A number of such cases have been reported. Astley Cooper alludes to three cases. In two of these the thigh was rotated inward, in the third case the leg and thigh were supinated. Mr. Moore's case demonstrates the possibility and manner of repair in these cases (Medico-Chir. Transactions, vol. xxxiv., p. 107). A man suffered a severe injury of the hip, which was diagnosticated and treated for fracture of the femoral neck. The thigh was not inverted or everted, only slightly flexed and adducted. The man recovered, and several years afterward died from other causes, when an autopsy revealed that the injury had been a fracture of the os pubis, ilium, and acetabulum, which allowed the head of the femur to pass through into the pelvis, the trochanter resting against the acetabulum. Similar cases have been reported by Kendrick and Morel-Lavellée. In all cases of fracture at the base of the acetabulum, without displacement of the head of the femur, the diagnosis usually remains doubtful. Main reliance must be placed on the manner in which the injury was inflicted, the intensity of the force applied, and the location of the pain. Accurate measurement will always furnish important negative evidence. In case of intrapelvic dislocation of the head of the femur through the fractured base of the acetabulum, the shortening of the limb and the approximation of the trochanter major toward the pelvis will be proportionate to the degree of penetration of the head and neck into the pelvis; rotation of the limb will not be practicable; flexion and extension will be found to be either impaired or rendered impossible; and at the same time the head of the femur may be felt within the pelvis on making a digital examination through the rectum. In the adoption of therapeutic measures it is necessary to ascertain the degree of impairment of the functional capacity of the acetabulum. If the head of the femur is retained firmly in its normal position the fracture will unite promptly and firmly without any special retentive measures. Rest in bed with the thigh slightly flexed and resting upon pillows will be sufficient to fulfil the local indications. If the pelvic ring is more extensively fractured, a plaster-of-Paris splint including the pelvis, both thighs, and the entire leg on the affected side, or Verity's suspension splint, will prove most efficient in securing immobility of the fragments, and will afford the greatest amount of comfort to the patient. When the base of the acetabulum has been perforated by the head of the femur it is of paramount importance to replace the dislocated bone and retain it *in situ* by a plaster-of-Paris dressing, or by applying extension by weight and pulley, as advised by Hueter, until the opening is closed by callus or connective tissue which will definitely prevent redislocation.

FRACTURE OF THE RIM OF THE ACETABULUM.—A number of well-authenticated cases of this accident have been reported, so that no further doubt can exist that some portions of the rim can be fractured without further injury to the acetabulum. Some years ago the writer collected from various sources twenty-seven cases of this kind of fracture, all of them supported by an accurate clinical history, some having been cases verified by a post-mortem examination. Dr. H. O. Walker, of Detroit, has in his possession a typical specimen of this kind, an illustration of which is here inserted (Detroit *Lancet*, July, 1879). In the text-books on surgery this subject is usually referred to under the head of complicated dislocations of the head of the femur. As this fracture usually involves the upper and posterior portion of the rim, the resistance to the head of the femur in that direction is lost, and as a result—either with the concurrent aid of some extraneous force, or even without such aid, simply by the force of muscular contraction—a dorsal dislocation of the thigh takes place, with adduction, flexion, and rotation of the thigh inward. The difficulty experienced in retaining the head of the femur in the acetabulum under these circumstances, as well as the obscurity of the diagnosis, imparts to this subject an unusual amount of interest. The older works on surgery mention direct and great violence as the only cause of fracture of the acetabulum; indeed, until more recently, it had been considered impossible for a fracture of the rim to take place without more extensive injury to the ilium. When the fracturing force is applied over the centre of the trochanter major, in the direction of the neck of the femur, the head of the bone is driven directly against the socket, and a stellate or perforating fracture of the base of the acetabulum is the result, according to the amount of violence applied; but if the force is applied in such a manner that it first rotates the femur outward or inward, then one margin of the acetabulum acts as a fulcrum to the neck, and the head is forced against the opposite side, and a linear fracture through the acetabulum, or a fracture of the rim, takes place. In such cases, the traction of the capsular ligament assists the head of the femur in producing the fracture of the rim, but independently of other causes such traction is insufficient to produce the injury. When the force is applied to the posterior part of the pelvis, the pelvis becomes the movable point, and the foot, if the leg is extended, or more frequently the knee, becomes the fixed point, and furnishes the necessary amount of resistance. These assertions have been verified by the writer by numerous experiments on the cadaver. At the moment the injury is received, it is essential for the thigh to be *abducted*, as adduction would favor a dislocation by the head of the femur gliding over the inclined plane of the internal surface of the acetabulum. The pelvis may be the fixed point, and the force may be transmitted through the femur by a blow or fall upon the knee. In most instances in which this accident occurred, the thigh was more or less flexed at the time of injury; hence, in the majority of cases, the upper and posterior segment of the rim was fractured, and the head of the femur dislocated into the upper sciatic notch or upon the dorsum ilii. Of the twenty-seven cases of fracture of the rim of the acetabulum, the extremes of the ages were eighteen and seventy-eight years, so that most of these cases occurred during the time of life when the individual is most exposed to grave injuries. It is also well to remember that, in young persons, dislocation and diastasis occur in preference to fracture, while in the aged, the altered position of the neck of the femur, as well as the increased fragility of its tissue, is a potent predisposing cause of fracture of the femoral neck.

FIG. 11.

The symptoms presented by a case of fracture of the rim of the acetabulum are those of dislocation and fracture combined; the symptoms of the former resemble ordinary dislocation, while those of the latter are directly referable to the broken bone itself. A certain degree of displacement of the head of the femur was present in all cases in which a diagnosis was made during life. Benjamin Travers believed that in some cases of fracture of the rim of the acetabulum the displacement takes place gradually some time after the injury has been received, but it is more probable that these were cases such as have been described by Hueter as inflammatory dilatation of the

acetabulum, the interstitial absorption of the margins of the cavity permitting the head of the femur to glide upward and backward. In 24 cases the direction of the dislocation is mentioned, and in 15 of these the head of the femur was dislocated upward and backward, in 4 into the great sciatic notch, in 2 directly backward, in 2 downward, and in 1 case forward. It will be seen, then, that in a large majority of cases that portion of the rim is fractured which is in the direction of the usual form of dislocation, so that the same injury which produces a dislocation may also cause a fracture, provided the force applied be sufficiently great, and the limb happen to be abducted at the time the injury is sustained.

The amount of shortening corresponds to the distance the head of the femur recedes from the socket. In Agnew's case no shortening could be detected on careful measurement. In all of the other cases in which mention is made of this symptom, it was present, but varied in degree from a quarter of an inch to four inches. If the head of the femur has left the socket the position of the limb is the same as in simple disocation, the direction being determined by the form of dislocation. Flexion to a greater or less extent was present in all cases in which reference is made to this subject. Inversion of the foot and rotation of the femur inward were present in fourteen cases, while the opposite condition existed in three cases, and in ten cases no mention is made of this symptom. When the dislocation was complete, the limb remained immovable in its abnormal position until reduction was effected. The characteristic symptoms of the injury are those which are referable to the fracture itself, and these are crepitus, easy reduction, and difficult retention. Crepitus is always an important symptom in ascertaining the existence of a fracture. If it is distinctly felt, there can be no further doubt that a bone has been broken. The presence of this symptom is of special diagnostic value in connection with this subject, as the symptoms of dislocation are usually so prominent as to engage the whole attention of the surgeon. In the cases reported, this symptom is alluded to eighteen times, and in the following terms: distinct, eleven times; faint, once; marked, twice; indistinct, once; slight, once; and in two cases it was absent. Bigelow lays great stress on this symptom as being essential to the diagnosis of fracture; his words are: "To afford satisfactory evidence, cases of this sort should have been identified by autopsy, or at least by crepitus." I believe that the crepitus is not the same as in ordinary fractures, for in these it is the result of two rough bony fragments rubbing against each other, while in the cases under consideration it is a roughness we obtain by rubbing an articular surface against a broken surface of bone; hence it is not quite as loud and distinct. The detached margin of the acetabulum, unless comminuted, remains attached to the capsular ligament, and is pushed in front of or to one side of the head of the femur at the time dislocation occurs, and is dragged after it when reduction takes place. In most of these cases it is clearly stated that crepitus was felt just before the head of the femur slipped into the socket, or at the moment reluxation took place, and in both instances it must have been produced by the head passing over the rough broken edge of the acetabulum. The ease with which reduction has been effected has attracted the attention of almost every observer. This is due to a more extensive laceration of the capsular ligament than occurs in simple dislocation, and also to the removal of the obstacle offered by the intact margin of the acetabulum. By the fracture of the rim, a more direct and even route has been prepared for the head of the femur to return to its socket.

Reluxation has always constituted the most perplexing feature of these cases. Its occurrence has usually led to a more thorough examination and correct diagnosis. It is well known that in ordinary dislocations of the hip-joint, when the bone has once been reduced, it remains in its place regardless of the after-treatment, differing greatly in this respect from the same lesion of the shoulder joint on account of the greater depth of the socket and the action of more numerous and powerful muscles for maintaining retention. Hueter believed that the cases of habitual dislocation of the hip joint reported by Karpinski may have been the result of injury to the rim of the acetabulum. Reluxation takes place from the inability of the defective margin to resist muscular contraction. The difficulty in retaining the bone is increased by the depth of the fracture and its approach to the junction of the superior and posterior portions of the rim. In this connection it is important to determine what portion of the rim is most frequently the seat of the fracture. In 20 of the cases special mention is made of this fact, as follows: superior portion of rim, 2; superior and posterior, 7; posterior, 5; posterior inferior, 4; inferior, 1; anterior, 1. When the inferior or anterior portion of the rim is fractured, there is no tendency to reluxation provided the limb is kept in the extended position and slightly inverted.

Diagnosis.—A most thorough and critical examination while the patient is profoundly under the influence of an anæsthetic is always necessary to establish a positive diagnosis. If spontaneous reluxation does not follow immediately after reduction has been accomplished, and there are sufficient symptoms present to warrant a suspicion of the presence of the injury, it would be advisable to test the functional integrity of the acetabulum by flexion, adduction, and rotation of the thigh; if any part of the rim has become defective by fracture, reluxation will be sure to take place. This manœuvre, associated with the presence of crepitus, may be regarded as the crucial test.

The differential diagnosis must consider fractures of the neck of the femur with displacement, and simple dislocation. To distinguish this fracture from fracture of the neck of the femur, it is necessary to compare their most prominent symptoms:

FRACTURE OF THE RIM OF THE ACETABULUM.	FRACTURE OF THE NECK OF THE FEMUR WITHOUT IMPACTION.
Position of Limb.	
Thigh and leg flexed, adducted, and rotated inward.	Thigh and leg straight and rotated outward.
Mobility of Limb.	
Mobility of limb diminished.	Mobility of limb increased.
Arc of Rotation.	
The trochanter major rotates in its normal arc.	The arc of rotation of the trochanter major is diminished.
Crepitus.	
Crepitation is not rough, and is felt as the head passes over the broken edge of the acetabulum.	Crepitation is rough, and is felt when the limb has been drawn down to its normal length.
Head of the Femur.	
The head of the femur is felt to be displaced.	The head of the femur is normal in its position.
Retention.	
The deformity reappears if by any movement of the limb the head of the femur is made to leave the socket.	The deformity reappears as soon as extension ceases.
History.	
Is most frequent in middle life and is the result of great violence.	If intracapsular in variety, it occurs in the aged and is the result of slight violence.

Crepitus and a tendency to reluxation are the symptoms on which we place the most reliance for differentiating this fracture from simple dislocation. Acupuncture, as advised by Middeldorpf, may be of great service to determine the existence of fracture of the rim. After reduction has been accomplished, a long stout needle, previously well disinfected, is passed through the tissues to the supposed seat of fracture. By lateral movements of its point the defect in the margin, as well as the roughness of its surface, is ascertained. An effort should now be made to fix the detached fragment with the point of the needle, and by rubbing it over the broken margin a rough crepitus is elicited.

Prognosis.—The prognosis must have reference to the preservation of life and the restoration of the utility of the limb. All of the old authors regarded fracture of the pelvic bones as a grave lesion, almost necessarily leading to a fatal termination. I believe that all uncomplicated fractures of these bones tend to recovery, and that death is attributable in most instances to a lesion of some important pelvic or abdominal viscera. In 23 cases in which the result is noted in this regard, 13 recovered and 10 died. The prognosis is less favorable if the floor of the acetabulum is also implicated in the fracture. Of 4 cases of this sort, only 1 recovered. In 9 cases out of the 13 that recovered, the limb remained in place after reduction, and the recovery was complete. In 4 cases redislocation took place, the limb assuming the same malposition as after simple unreduced dorsal dislocation of the femur.

Treatment.—The indications to be fulfilled in the treatment of this class of injuries are: (1) to reduce the dislocation; (2) to retain the head of the femur in the socket until union has taken place between the fragments. The dislocation may be reduced by manipulation or by extension; in both instances flexion constitutes an important step in the operation. Bigelow says: "These displacements, especially the displacement backward, demand the usual attempts at reduction by flexion. Although the bone inclines to slip from the socket it can be retained there, in cases of a sort heretofore considered difficult of treatment, by angular extension, with an angular splint attached to the ceiling, or some other point above the patient; or if any manœuvre has reduced the bone, the limb should be retained, if possible, in the attitude which completed the manœuvre." In 17 of the cases reported, the manner of reduction is specified as follows: by extension, 11 (in most of these cases extension and flexion were combined); by manipulation, 2; by manipulation and extension, 1; by manipulation over Sutton's fulcrum, 1; by extension with pulley, 2. In all but one of the cases the displacement was corrected without difficulty. As in most instances a diagnosis cannot be made before reduction has been accomplished, surgeons will resort to their favorite methods of reduction. Should the nature of the lesion be determined beforehand, traction in the direction of the broken edge of the rim, and rotation of the limb inward, will readily restore the normal relation of the parts. As we possess no direct measures of keeping the fractured surfaces in apposition, all our efforts must be directed toward preventing relaxation by appropriate position and fixation of the limb and pelvis. The depth and extent of the fractured margin, as well as the location of the fracture, will determine the difficulty in retaining the head of the femur in its normal position. If sufficient depth of the upper portion of the rim is left to serve as support to the head of the bone, all that is necessary is to dress the thigh in the abducted position, so as to press the head of the femur against the floor of the acetabulum. As the contusions of the soft parts about the hip and pelvis are severe, a plaster-of-Paris splint cannot be applied as a primary dressing. The healthy limb and pelvis should always be included in the retentive dressing. Bonnet's wire breeches, Dzondi Hagerdorn's apparatus, or Hamilton's splint, as advised by him in the treatment of fractures of the femur in children, will be found sufficient to maintain retention. After the swelling in the soft parts has subsided, nothing more perfect could be devised than a plaster-of-Paris dressing, including both limbs and the pelvis.

When nearly the entire depth of the upper or posterior portion of the rim has been detached, muscular contraction must be counteracted by permanent extension with the weight and pulley, and immobility of the joint should be secured by appropriate splints. In cases of this sort, angular extension with an angular splint, as advised by Bigelow, will answer an admirable purpose. The unbroken part of the rim should be made the support of the head whenever practicable. Thus, for example, when the posterior part of the rim is fractured the thigh should be dressed in the position of hyperextension; a broad, firm, pelvic band, with a compress above the trochanter, being employed to aid in keeping the bone in place, in approximating the fractured surfaces, and in preventing muscular spasms.

The treatment should be continued for a sufficient length of time to secure a firm union of the detached fragment with the broken rim, which, as in other fractures, generally requires from four to six weeks. The patient must be directed to exercise great care in the use of the limb for a considerable length of time after all dressings have been removed, so as to obviate any undue pressure against the recently repaired rim of the acetabulum.

N. Senn.

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ACETAL.—Ethylene-di-ethyl-ether—di-ethyl-aldehyd. $CH_3CH(OC_2H_5)_2$. This is a preparation obtained by distilling a mixture of acetic aldehyd and alcohol in the presence of some dehydrating agent such as sulphuric acid. It is a colorless, limpid liquid, very volatile, and with a rather agreeable ethereal odor. On the tongue it is rather sharp, but leaves a pleasant nutty after-taste. It is soluble in eighteen parts of water and in twenty-five parts of chloroform; and it is miscible in all proportions with alcohol and ether. It boils at 104°-106° C. (219°-222° F.), and its specific gravity at 20° C. is 0.831. Its particular use is as an agreeable sedative, and it also has some power as a hypnotic and local anæsthetic. As a hypnotic, however, its effects are too transient to be of much value; and the more volatile ethers are preferable for the production of local anæsthesia. As a sedative in headache and nausea one to three drachms may be given in emulsion with orange flower or cinnamon water, and may be administered either by mouth or by rectum.

Acetal is also the trade name for a headache remedy which consists of various volatile oils and acetic ether dissolved in alcohol. *W. A. Bastedo.*

ACETAMINOL.—Para-acetamido-benzoyl-eugenol, $C_6H_3.OCH_3.C_3H_5.O.CO.C_6H_4NHCH_2CO$, prepared by the action of benzoic and amidoacetic acids on eugenol. It is in whitish scales or a crystalline powder, is practically insoluble in water, and is soluble in alcohol. It has the general antiseptic action of benzoyl eugenol combined with more or less power to reduce the temperature. It has been used as an intestinal antiseptic and in the treatment of pulmonary tuberculosis. Dose, 5 to 15 grains. *W. A. Bastedo.*

ACETANILID.—$C_6H_5.NH.C_2H_3O$ (Phenylacetamide, Antifebrin). Of the host of new remedies that have been manufactured during the past few years, this is one that has received general approbation and has sustained the reputation with which it was introduced. Since its introduction in 1886, by Drs. Kahn and Hepp, it has been extensively employed, without detracting from their estimate of its virtues. Further study has established its antipyretic and analgesic properties, and were it not that in phenazone and phenacetine we have drugs with a similar action it would be prized as of inestimable value.

It now occupies a position in the new pharmacopœias of the United States and Great Britain—in the former as *acetanilid*, "an acetyl derivative of aniline"; in the latter as *acetanilide*, "a crystalline substance obtainable by the action of glacial acetic acid on aniline, and subsequent purification." It occurs as white, shining micaceous, crystalline laminæ, or a crystalline powder, odorless, having a faintly burning taste. Soluble at 59° F. in 194 parts of water and in 5 parts of alcohol; in 18 parts of boiling water; also soluble in 18 parts of ether and easily soluble in chloroform. When heated to 235.4° F. it melts. Upon ignition it is consumed without leaving a

residue. It is neutral to litmus paper. A simple test is to add a cold saturated aqueous solution to ferric-chloride test solution; the color of the latter should not be changed, indicating an absence of aniline salts.

Acetanilid exercises a depressing action upon the gray matter of the nervous system, and a destructive action upon the constituents of the blood. Upon the former depends its therapeutic properties, while the latter is an altogether undesirable effect.

Its action on the nervous system is most marked upon the gray matter of the spinal cord, by which the power of conducting painful impressions is greatly reduced, and at the same time it lessens the receptivity of the brain. The brain retains its clearness, but motive power and conduction are affected in a slight degree.

Its effect upon the medullary centres is to reduce the frequency and force of the pulse, depress respiration, and by relaxing the blood-vessels to promote the flow of blood to the surface and lessen blood pressure. In very large doses these effects are intensified, and upon animals the drug has caused anæsthesia, loss of reflex action, weakened circulation, convulsions, coma, and general paralysis.

In ordinary doses its action upon the blood is not noticeable, but if its use is persisted in it leads to anæmia. In over-doses it acts directly upon the hæmoglobin, producing methæmoglobin and lessening the oxidizing power of the blood. The blood may become of a dirty-brown color and hæmoglobinuria may be present.

When toxic symptoms arise there is generally a sudden sense of weakness and oppression, with a rapid lowering of temperature and bluing of finger nails and lips; this is accompanied or followed by vertigo, giddiness, noises in the ears, dilated pupils, cold extremities, subnormal temperature, shallow breathing, feeble pulse, nervous twitchings, convulsions, and coma. It is after large doses, or during the prolonged use of the drug, that these symptoms of poisoning are met with, but many instances are reported in which an ordinary therapeutic dose has produced an alarming condition.

In the administration of the drug there are many points to be considered which influence its action. As the effect of the dose is continued for two or three hours, the dose should not be repeated until that interval has elapsed. When the use of the drug is persisted in for some time, a day of freedom from its use should occasionally be allowed to intervene, as it undoubtedly possesses a cumulative action. Many instances are reported in which severe toxic symptoms have followed the same dose that had been given for some days with only beneficial effects. When the patient is anæmic, and in the debilitated and aged, the toxic symptoms more readily supervene, and in women, during the few days previous to menstruation, the condition of the blood is supposed to favor the decomposition of the drug and increase its action. The time of the dose, in relation to the natural rise or decline of temperature, is of importance; when given with the increase of fever, its action is slower and within control; but if its effect coincides with the decline, the fall will be rapid and probably in excess of what is expected.

The tendency to cause profuse sweating and cyanosis has unfortunately engendered in many a sense of dread which has restricted its use. This toxicity is greatly over-estimated and should not be feared if the dose and mode of administering are attended to. It is rather a danger-signal far in advance of any serious consequences.

The cyanosis and depression are not of long duration and are rapidly overcome. Fatal cases are rare, and very large quantities of the drug have been taken without causing death. A case is reported in which teaspoonful doses were taken at short intervals until one ounce was disposed of, and in another instance seven and a half drachms were taken with suicidal intent. In both cases recovery followed.

Kahn and Hepp in their original papers stated that one-fourth of a gramme (3.85 grains) was a sufficient dose, and subsequent writers have insisted on the efficacy of even smaller quantities.

Instead of the seven or ten grains so frequently given, the consensus of opinion now points to three or four grains as a more proper initial dose in every case in which its use is begun, to be increased as the individual susceptibility is learned.

During the past few years it has become evident that, when applied to raw surfaces, acetanilid may be absorbed and produce its physiological effect. In some instances acute poisoning has followed this use of the drug in infants and children. In one case the umbilical cord was dressed with about sixty grains of the crystals. On the second day prostration and cyanosis were marked, and continued for three days. In another case between twenty and forty grains were applied to a burned surface. When used for two successive days the same toxic symptoms arose. Many other cases have been reported. In one, an infant four days old, death resulted in four hours.

A distressing itchiness and burning of the skin, accompanied by a varying degree of erythema, has occasionally been noticed. It is not so common as during the use of other coal-tar products, but many cases have been recorded.

To counteract the poisoning, stimulating treatment is indicated. Warmth to the extremities and surface; alcohol, ether, and camphor by the mouth or hypodermically; belladonna is particularly recommended, four drops of the tincture every half-hour for four doses, afterward at longer intervals, having proved of service. Strychnine is also useful. The inhalation of oxygen is indicated. In extreme prostration the transfusion of saline solution has been adopted with benefit.

Acetanilid in fever is used solely as an antipyretic, and as such it has been classed as one of the best we possess. It is utilized in typhoid fever, pneumonia, phthisis, erysipelas, acute rheumatism, and in all conditions in which hyperpyrexia is present. It was thought by some to have specific properties in acute rheumatism, but such a view is no longer tenable; the duration of the disease is not affected, complications are not prevented, nor does it guard the patient against relapses. It reduces the high temperature and relieves the discomfort and distress that are present, and its sedative action on the nervous system adds to its calming and refreshing effect. Its continuous administration is not advised, but only its use when the temperature is such as to require interference.

In phthisis it proves particularly soothing. In the hyperpyrexia of pneumonia it is used with advantage, but in this condition, as well as in advanced phthisis, where the respiratory tissue is reduced, it must be given with caution.

In acute rheumatism it relieves the painful and swollen joints and reduces the temperature. When the pains are severe larger doses are required than in other febrile affections. Its action is generally thought not to be so efficacious as that of antipyrin or salicylate of soda.

Its analgesic properties have proved almost as decided as its power of reducing pyrexia. It is particularly useful in all pains due to irritation of the sensory nerves, or pains of a reflex character, such as those of locomotor ataxia, neuralgia, sciatica, lumbago, pains after operations, ovarian and menstrual irritation; also in migraine, nervous headaches, and the headaches of growing children. In all paroxysmal pains it has proved equally successful.

It has been recommended and tried in epilepsy and chorea, but without much advantage.

Quite recently it has been lauded as a very effective remedy for threatened premature expulsion of the ovum. It is stated that from seven to ten grains will lessen the uterine contraction and pain and check the hemorrhage; the dose to be repeated at intervals of two or three hours.

In the diseases of infancy it has proved of decided usefulness. Its effects are of longer duration and the toxic symptoms are not so liable to follow its use. In scarlet fever, measles, pneumonia, etc., its action has been most gratifying, reducing fever and restlessness and inducing a quiet and refreshing sleep. In whooping-cough it is

also used with success; its action promotes expectoration and reduces the frequency and duration of the paroxysms.

Its non-irritating and antiseptic properties have led to its employment as a dressing after surgical operations, as well as for wounds of every description. It is also recommended as a substitute for iodoform in venereal sores. It may be dusted pure over the parts or mixed with boric acid in varying proportions. A glycerol is made by adding one part to forty of cold sterilized glycerin. If a stronger preparation is desired, a solution of acetanilid in alcohol is prepared, twenty grains to the ounce, and one ounce of this mixed with four of glycerin. It may also be combined with vaseline or collodion.

Beaumont Small.

ACETIC ACID.—Acetic acid, $HC_2H_3O_2$, the well-known acid of vinegar, is a body fluid at ordinary temperatures, and miscible in all proportions with water. Mixtures of the acid and water in different proportions constitute the different grades of the acid in commerce. Strong acetic acid is caustic, largely through its property of dissolving the formed material of the connective tissues to a pultaceous translucent substance. Being caustic, it is of course irritant, and swallowed in concentrated condition operates as a corrosive poison, the effects and symptoms being substantially the same as in poisoning by the strong mineral acids. Two cases of death have been recorded. The treatment is similar to that to be employed in case of poisoning by a mineral acid. In non-corrosive strength of solution (five or six per cent., the equivalent of vinegar), acetic acid produces the usual local effects of the sour acids—exciting the flow of saliva and tending to oppose sour fermentation of the food—and is also distinctly astringent. Inhaled, the fumes are reviving in faintness and may relieve headache.

Acetic acid has many uses in pharmacy. Recently it has been urged strongly by high authority that the Pharmacopœia should substitute acetic acid largely for alcohol as a menstruum for the preparation of extracts, and it is probable that some such course will be followed. It has even been proposed that this class of extracts shall bear the special name "Acetracts." In medicine the strong acid may be employed as a caustic, as to warts or cancers, and the weak acid used to make refreshing acid draughts in fever, or cooling lotions in inflammatory skin affections. Acetic acid is official in the U. S. Pharmacopœia in the following forms:

Acidum Aceticum Glaciale, Glacial Acetic Acid.—This is defined to be "nearly or quite absolute acetic acid." It is "a clear, colorless liquid, of a strong, vinegar-like odor, and a very pungent, purely acid taste. When the acid is cooled to a temperature as near as possible to 15° C. (59° F.), but yet in a liquid form, its specific gravity should not be higher than 1.058, corresponding to at least ninety-nine per cent. of absolute acid. At a temperature somewhat below 15° C. (59° F.), the acid becomes a crystalline solid" (U. S. P.). This grade of the acid is for pharmaceutical uses.

Acidum Aceticum, Acetic Acid.—The grade of acid thus simply named is a "liquid composed of thirty-six per cent., by weight, of absolute acetic acid and sixty-four per cent. of water." It is "a clear, colorless liquid, having a strong, vinegar-like odor, a purely acid taste, and a strongly acid reaction. Specific gravity, about 1.048 at 15° C. ((59° F.). Miscible with water and alcohol in all proportions. When heated, the acid is volatilized without leaving a residue" (U. S. P.). This grade of acid is somewhat stronger than the best samples of the commercial so-called "No. 8" acid, these "No. 8" acids rarely being of higher specific gravity than 1.030 and often sinking to 1.025 or less (Squibb). This is the acid that results from the purification of the crude acid—*crude pyroligneous acid*, so called—obtained by the destructive distillation of wood.

Acetic acid of the present quality is sharply irritant and even mildly caustic. Dangerous symptoms have resulted from swallowing it, undiluted, in quantity of two or three ounces. The acid may be used as a mild caustic, but its principal uses under its own form are pharmaceutical.

Acidum Aceticum Dilutum, Diluted Acetic Acid.—This preparation is compounded of one part, by weight, of acetic acid of the foregoing grade and five parts, by weight, of distilled water. It "contains six per cent., by weight, of absolute acetic acid. Specific gravity, about 1.008 at 15° C. (59° F.)" (U. S. P.). This diluted acid is of the strength of the best qualities of vinegar, and is better than vinegar for all the purposes of the same, medicinal or dietetic. Squibb says: "If one part of alcohol be added to about two hundred and fifty-six parts of this diluted acetic acid—that is, about half a fluidounce to the gallon—and the mixture be set aside for a few weeks (the longer the better), enough acetic ether is generated to give it the full, clean aroma of fine vinegar, and then for table use it is very far superior to any vinegar made in the ordinary way by fermenting cider."

Diluted acetic acid is the most convenient grade of the acid for medicinal use, and has also, in the U. S. Pharmacopœia, superseded vinegar for pharmaceutical purposes. For an acid draught a five-per-cent. addition to water is appropriate, and for a lotion a twenty-five-per-cent. addition. The popular notion that the habitual use of vinegar tends to deterioration of nutrition and health is certainly not true of a moderate indulgence, if indeed it be true at all.

Edward Curtis.

ACETIC ETHER.—Under the title *Æther Aceticus*, Acetic Ether, the U. S. Pharmacopœia makes official a preparation consisting of the ethereal salt, *ethyl acetate*, with a little contaminating alcohol and water. Acetic ether is described as "a transparent, colorless liquid, of a fragrant, and refreshing, slightly acetous odor, and a peculiar acetous and burning taste. Specific gravity, 0.893 to 0.895 at 15° C. (59° F.). Boiling point, about 76° C. (168.8° F.). Soluble in about eight parts of water at 15° C. (59° F.); miscible in all proportions with alcohol, ether, fixed and volatile oils. Acetic ether is readily volatilized, even at a low temperature. It is inflammable, burning with a yellowish flame and an acetous odor" (U. S. P.). Acetic ether should be kept in well-stoppered bottles and away from lights or fire.

The effects of acetic ether upon the animal economy are similar, in a general way, to those of common ether, the most important point of difference being that acetic ether is the slower in operation. For this reason this ether is not available as a surgical anæsthetic; but, on the other hand, by reason of its agreeable odor, it makes an excellent and grateful cardiac stimulant, antispasmodic, and carminative, taken internally. Used externally, it may serve to mask disagreeable odors. It may be given internally, in quantities ranging from fifteen to thirty drops, well diluted with water or with some medicinal preparation, to which the ether is added as an adjuvant or corrigent.

Edward Curtis.

ACETONE.—Acetone, C_3H_6O, the ketone of acetic acid, called also *pyroacetic spirit* and *pyroacetic ether*, is a colorless, limpid, and inflammable liquid of pungent quality, miscible in all proportions with water, alcohol, and ether. Its effects upon the animal system are, doubtless, of the general nature of those of the volatile alcohols and ethers, but the substance has never been systematically employed as a medicine.

It is used for chemical purposes in the manufacture of chloroform, and as a solvent for fats and resins.

It occurs normally, in small amounts, as an ingredient of blood, urine, etc.

Edward Curtis.

ACETONURIA.—DEFINITION.—The presence in the urine of a pathological quantity of acetone, $CO(CH_3)_2$.

HISTORICAL.—Petters in 1857 discovered acetone in the urine of a patient suffering from diabetic coma, and three years later Kaulich demonstrated its occurrence in ordinary cases of diabetes and added a clinical picture of the condition known as acetonæmia.

Kussmaul in 1874, writing on diabetic coma, first threw doubt on the previously expressed idea that a definite relation existed between diabetic coma and acetonuria, while Gerhardt later on showed the occurrence of diacetic acid in the urine, a substance which has, clinically, even greater importance.

OCCURRENCE.—Physiologically, acetone occurs in the urine in very minute proportions, probably never more than .02 gm. being excreted in twenty-four hours. Pathologically, more than 5 gm. have been in the daily quantity of urine.

The main conditions under which increased acetone is found may be briefly summarized as follows:

1. Alimentary, *i.e.*, according to diet; withdrawal of carbohydrates; this may reach 0.7 gm. after prolonged dieting.
2. Diabetes, especially after some duration of the disease and with proteid diet or increased fats.
3. Fevers (often with diacetic acid and β oxybutyric acid as well); infectious diseases, *e.g.*, enteric fever, sepsis, pneumonia, exanthems, tuberculosis, acute inflammatory rheumatism; in the fevers it occurs only in prolonged cases, probably because of the nature of the diet; acute fevers present no increased acetonuria.
4. Starvation and inanition; cachexia; early carcinoma of stomach.
5. Digestive disturbances with auto-intoxication; peritonitis.
6. Pregnancy with dead fœtus.
7. Nervous lesions and mental disease; tabes; general paralysis; melancholia, etc.
8. Artificially induced general anæsthesia (chloroform).
9. Experimental—after extirpation of the solar plexus or of the pancreas.
10. Medicinal—phlorizin; chronic morphinism.

Source.—There is no doubt that acetone elimination bears a definite relation to the increased destruction of proteids, its occurrence in starvation, fevers, etc., bearing out this theory. It is not yet determined whether the amount excreted depends merely on the quantity of tissue proteid destroyed or upon the total proteid used up by the metabolism. Von Noorden and Honigmann hold that the destruction of tissue proteid is the essential feature. Certainly acetone elimination is not always increased with greater ingestion of proteids; in fact, too much proteid may diminish the degree of acetonuria. Fatty diet seems to increase acetone elimination; indeed, Geelsuyden is of the opinion that disintegration of fat either in the tissues or in the food is the main cause of acetonuria. Again, while increased ingestion of carbohydrates causes decrease of acetone excretion, a diminution of this in the diet is followed by marked acetonuria.

There seems to be no mutual relation between nitrogen elimination and acetonuria.

In diabetic urine three substances frequently occur together and seem to have some definite relation to one another, though their exact interdependence is not as yet understood. These substances are acetone, diacetic acid, and β oxybutyric acid. We can readily derive one from the other, *e.g.*, β oxybutyric acid from diacetic acid, or again by oxidation β oxybutyric acid forms acetone and carbonic acid. These three exist also together in other conditions than diabetes, *e.g.*, in starvation, severe infections, fevers, etc., and their relative proportions seem to vary without respect to their origin.

Probably, as Naunyn suggests, β oxybutyric acid is usually formed first and is the mother substance for the others, and the amounts of each formed depend on a great variety of conditions; thus, for example, a very marked alkaline state of the blood favors diacetic acid formation, while again acetone forms best in an acid urine, and so on. Certainly the degree of acetonuria does not depend regularly on the amount of β oxybutyric acid.

Clinical Significance.—In all probability the acetone *per se* is harmless and the toxic symptoms are produced by the diacetic and β oxybutyric acids; and possibly also others, *e.g.*, lactic acid or volatile fatty acids, come into action, too, at times. At all events, it is the *acid intoxication* (or excessive acidosis, as it has been called) that induces the serious changes which occur. Patients manifesting this acid intoxication usually get diabetic coma if no intercurrent affection occur to carry them off.

The PROGNOSIS, then, depends rather upon the evidence of acidosis than of acetonuria to a large extent, and Hallervorden has for this reason suggested the importance of frequent estimation of the ammonia eliminated, this giving a fairly accurate idea of the acid intoxication. (More than 3 gm. of NH_3 in twenty-four hours indicates excessive acidosis, while if more than 4 gm. exist, the onset of diabetic coma is almost certain, even though due treatment temporarily diminish the amount of NH_3 elimination.) This theory is proven, too, by Stadelmann's and Minkowski's observations, that diminished CO_2 was in the blood (*i.e.*, less alkalinity), and by the fact, too, that in severe diabetes the sudden restricting to meat diet (*i.e.*, acid) is often followed by coma.

The acetone is to some extent, however, in definite ratio to the intensity of the diabetes, and the presence of a large quantity is of grave import—though not as a prodrome of approaching coma, as Hirschfeldt once supposed. Intercurrent fevers, *e.g.*, pneumonia, may greatly increase the acetone temporarily, and with convalescence the quantity may return to its previous amount. So it was in the case of a diabetic whose urine increased during an intercurrent pneumonia from 0.4 gm. to 4 gm. acetone, daily, and with convalescence the amount returned to 0.4 gm. in the twenty-four hours; coma did not supervene and the patient lived for months afterward, until fatal marasmus came on. It is well, however, to follow the acetone excretion in diabetes, for its increase is so frequent with threatening symptoms;—hence the benefit, at such a time, of judicious administration of carbohydrates.

The DIAGNOSTIC significance of acetonuria lies in the fact that its presence to any extent with glycosuria renders the diagnosis of diabetes certain.

Tests.—Before testing for acetone one should ascertain the possible presence of diacetic acid, which by decomposition often forms acetone. For this, Gerhardt's reaction is to be tried and the following three steps must be taken:

Fifteen cubic centimetres of urine are treated with dilute (not too acid) ferric chloride so long as it gives a precipitate. The precipitate (ferric phosphate) is filtered and more ferric chloride added to the filtrate. In presence of diacetic acid a claret-red color appears. A second portion of the urine is boiled and the same test repeated after cooling. A negative result should follow, because the diacetic acid was decomposed by the boiling. (If a positive result were again obtained it would indicate the presence of acetic or some other acid in the urine.)

A third portion is next acidified with sulphuric acid and shaken with ether. The ether is removed and shaken with a very dilute aqueous solution of ferric chloride, when the watery layer becomes violet red or claret red. The color disappears on warming or after standing twenty-four hours.

In the *absence of diacetic acid* we proceed to test directly for acetone. No single test for acetone is completely satisfactory; hence the necessity of employing several as confirmatory evidence. One may use the urine as it is, although it is more accurate to resort first to distillation. About 250 c.c. of urine are boiled after faintly acidifying with sulphuric acid, and, a good condensation being secured, all the acetone will distil in the first 20 c.c.

When *diacetic acid is present* the urine should first be rendered faintly alkaline and carefully shaken up in a separator funnel with ether (the ether must be free from alcohol and acetone). The removed ether is then shaken up with water, which takes up the acetone, and this watery liquid is tested.

Qualitative Tests.—Lieben's Iodoform Test. Treat a few cubic centimetres of the distilled urine (which should be freshly voided always) with some sodium hydrate and iodine potassic iodide solution and gently warm. With traces of acetone a yellow precipitate of iodoform occurs, and this will be recognized by its odor and by the hexag-

onal plates or stellate crystals. While this test is delicate enough for acetone, there are many other constituents of the urine and other substances (at least seventeen) which yield a similar reaction. Among them is alcohol; hence the possibility of error from using an alcoholic solution of iodine to make up one of the reagents—which must, of course, be avoided. Gunning modified the test by using an alcoholic solution of iodine and ammonia instead of the mixture mentioned above. A black precipitate of iodide of nitrogen results, and this, in the presence of acetone, gradually disappears, leaving the yellow iodoform behind. The test, though not quite so delicate, is more accurate, neither alcohol nor aldehyde producing a similar result; and, moreover, it is eminently suited for clinical purposes, in view of the temptation to test without the time-absorbing distillation.

Legal's Sodium Nitroprusside Test. Treat a few cubic centimetres of the urine with two or three drops of a freshly prepared concentrated solution of sodium nitroprusside and add a thirty-per-cent. solution of caustic potash. A ruby red color appears, which changes to yellow. Any urine may give this reaction. But if acetone be present in pathological amount the addition of acetic acid changes the color to a purple red or violet.

Parakresol and creatinin give somewhat similar reactions. In presence of the former, however, the yellow color changes to pink on addition of acetic acid, while with the latter a *saturation* with acetic acid gives a yellow color, soon changing to green and blue. Acetone, under similar conditions, gives a carmine color. Fehr modifies this test by floating the acetic acid on the urine as the color changes to yellow. A violet is produced at the line of contact, its intensity being proportionate to the amount of acetone present.

Notwithstanding its frequent commendations for clinical purposes, Legal's test is certainly unreliable unless the urine be first distilled.

Le Nobel's test is similar. One adds an alkaline solution of sodium nitroprusside (so dilute as merely to give a faint reddish tint to the solution) to the urine; a ruby red color is obtained, soon changing to yellow. On boiling and adding the acid a greenish blue or violet results.

Penzoldt's Indigo Test. Treat the urine with a warm saturated and then cooled solution of orthonitrobenzaldehyde and add caustic soda. If acetone be present the liquid becomes first yellow, then green, and finally indigo forms, which may be dissolved in chloroform.

Chautard takes fuchsin solution into which a current of sulphurous acid gas has been passed. This decolorizes the liquid and gives it a clear yellow tint. When added to urine containing acetone a deep violet color is produced.

Reynolds' mercuric oxide test depends on the power of acetone to dissolve freshly precipitated mercuric oxide. A mercuric chloride solution is first precipitated by alcoholic caustic potash. The urine is added to this and the mixture well shaken and filtered. If acetone be present the filtrate contains mercury, which may be detected by the black color on adding ammonium sulphide.

Reynolds' and Gunning's tests are particularly recommended for delicacy and reliability combined.

Quantitative Test.—Huppert's modification of Messinger's is that most recommended; Lieben's iodoform test being the method on which it is based.

Acetone forms iodoform when treated in an alkaline solution with iodine. By treating the urine with a known amount of iodine one need simply estimate the quantity unused by the iodoform to know how much has been combined. This can be done by titration with sodium thiosulphate solution. For the details of the method the reader is referred to Huppert's "Analyse des Harns," 1898. *Charles F. Martin.*

ACETO-PHENONE-ORTHO-OXY-QUINOLIN, $C_9H_6NO.CH_2.CO.C_6H_5$, is made by the action of an alkali on a solution of acetophenone chloride and orthoquinolin. It is an odorless, tasteless, strongly basic liquid insoluble in water and soluble in alcohol, ether, and chloroform. It forms salts with the acids, and is given in doses of one to three minims as a hypnotic or for neuralgia. Its uses are the same as those of acetophenone (see *Hypnone*), but it lacks the penetrating odor and pungent taste.

W. A. Bastedo.

ACET-ORTHO-TOLUID (Ortho-tolyl-acetamid).

ACET-PARA-TOLUID (Para-tolyl-acetamid), $C_6H_4(CH_3)NH.COCH_3$.

These isomers are produced by the prolonged boiling of glacial acetic acid with orthotoluidin and paratoluidin respectively. They occur in colorless, needle-shaped crystals, almost insoluble in cold water and readily soluble in alcohol and ether. Chemically they differ from phenacetin only by the substitution of a methyl for an oxyethyl group, and they are valuable as antipyretics. The dose is from 5 to 15 grains. *W. A. Bastedo.*

ACETYLENE. See *Carbon, Oxids of.*

ACETYL-THYMOL (thymol acetate), $C_{10}H_{13}O.CH_3CO$, is a colorless liquid with an aromatic odor and pungent taste, and is used as an antiseptic. *W. A. Bastedo.*

ACIDS.—*Fatty Acid Series*, $C_nH_{2n}O_2$.—Fatty acids are found in the body chiefly in combination with glycerin in the glycerides or neutral fats of adipose tissue. They are also found combined with alkalies, as soaps, and, in small quantities, as free fatty acids. Free fatty acids occur in the intestine as a result of the breaking up of neutral fats in pancreatic digestion. Some of the lower members of the series are found free in blood and sweat. As we ascend the series, the molecules become more complex and the melting and volatilizing points rise. For each acid they vary slightly, according to the mode of preparation. Many fatty acids crystallize in characteristic forms. The following are of most physiological importance:

Formic acid, $H.COOH$, is found combined as salts in minute traces in normal urine, and in increased amount in certain diseases with deranged metabolism, such as leucocythæmia and diabetes. It is present in the stings of certain insects, giving them their irritating qualities. It is a colorless liquid, of strong odor, volatilizing at 100° C.

Acetic acid, $CH_3.COOH$, is found in the intestine and sometimes in the stomach as a result of fermentation processes, occurring in carbohydrates and higher fatty acids. Its salts are present in normal urine in traces, and in increased amount in diabetes and leucocythæmia. In the diseases named, it is also found in the urine combined with acetyl, $CH_3.CO$, to form diacetic acid, $CH_3.CO.CH_2.COOH$. Acetic acid has a characteristic odor like vinegar, a sour taste, and forms transparent crystals which melt at 17° C.

Propionic acid, $CH_3.CH_2.COOH$, occurs occasionally in sweat. It is present in the blood, urine, and vomit of certain diseases. It is the first fatty acid to form a neutral fat with glycerin. It has an odor like acetic acid and volatilizes at 142° C.

Butyric acid, $CH_3.(CH_2)_2.COOH$, is found in the intestines and occasionally in the stomach, as a result of fermentations. It may be formed from the decomposition of proteids, carbohydrates, fatty acids higher in the series, or lactic acid. It is found in sweat, and traces have been demonstrated in blood and urine. It is present in milk and butter, combined with glycerin as butyrin. Butyric acid is an oily liquid, volatilizing at 162.3° C. and solidifying at −19° C.

Isovalerianic acid, $(CH_3)_2.CH.CH_2.COOH$, is found in cheese, the sweat of the foot, and the urine of certain diseases. It is a product of proteid decomposition. It is found combined as a neutral fat in dolphin blubber. It is an oily, colorless liquid, smelling like rotten cheese, and volatilizing at 176.3°.

Caproic acid, $CH_3.(CH_2)_4.COOH$, is found in the fæces and sweat, also in cheese, is formed from putrefaction of proteids, and occurs as a glyceride in butter. It is an oily, colorless liquid, with a faint, unpleasant smell. It volatilizes at 205° C. and solidifies at −18° C.

Caprylic acid, $CH_3,(CH_2)_6,COOH$, and

Capric acid, $CH_3,(CH_2)_8,COOH$, are found in sweat, in cheese, and as glycerides in butter. Caprylic melts at 16.5° C. and volatilizes at 236° C. Capric melts at 30° C. and volatilizes at 270° C.

Lauric acid, $CH_3(CH_2)_{10},COOH$, and

Myristic acid, $CH_3,(CH_2)_{12},COOH$, are present as glycerides in human fat and in butter, also as compound ethers in spermaceti. Lauric acid melts at 43.6° and myristic at 53.8° C.

Palmitic acid, $CH_3,(CH_2)_{14},COOH$, is found as a glyceride in all animal fats and as compound ethers in spermaceti and beeswax; it is also found combined with cholesterin in wool fat (lanolin). It melts at 62° C.

Stearic acid, $CH_3,(CH_2)_{16},COOH$, is found combined like palmitic acid in animal fats and spermaceti. It melts at 69.2° C. Margaric acid is a name sometimes applied to a mixture of palmitic and stearic acids.

Arachidic acid, $CH_3,(CH_2)_{18},COOH$, is found in butter as a glyceride. It melts at 75° C.

Cerotic acid, $CH_3,(CH_2)_{25},COOH$, is found free in beeswax. Combined as cetyl ether, it forms the principal part of Chinese wax. The free acid forms granular crystals, which melt at 78° C.

Acrylic Acid Series, $C_nH_{2n-2}O_2$.—Some of the higher members of this series form compounds with glycerin, resembling the neutral fats. The most important member of this group physiologically is—

Oleic acid, $CH_3,(CH_2)_{14},(CH)_2,COOH$; it is found united with glycerin in all the fats of the body, as a liquid fat, olein, which holds the higher fats of the fatty acid series in solution at the body temperature.

Glycolic Acid Series, $C_nH_{2n}O_3$. — Carbonic acid, OH,COOH, is unknown in its free state, being doubtless too unstable to exist. Its salts, however, are present in large quantities in the body, and play an important part in the alkalinity of the tissues and fluids. Its corresponding oxide, CO_2, is the principal form in which carbon leaves the body.

Glycolic acid, H,CHOH,COOH, does not occur in the body.

Lactic acid, CH_3,CHOH,COOH, exists in three isomeric varieties:

1. Fermentation lactic acid is present in sour milk, and in the stomach and intestines during digestion. It is also found in small quantities in the muscles and brain, and in diabetic urine. It is a colorless or faintly yellow liquid of syrupy consistency, and is distinguished from the two following by being optically inactive.

2. Paralactic or sarcolactic acid is the principal acid of meat extracts and of muscle, and is also found in numerous glands. It is present in the sweat in puerperal fever, and in the urine after severe fatigue, in acute yellow atrophy of the liver, and in phosphorus poisoning. It is dextro-rotatory to polarized light.

3. A third lævo-rotatory lactic acid has been obtained by the fermentation of cane sugar by a special bacillus.

Oxybutyric acid, CH_3,CH_2.CHOH.COOH, found along with diacetic acid and acetone in the blood and urine of diabetes, is an odorless syrupy liquid, which mixes freely with water, alcohol, and ether, and rotates polarized light to the left.

Oxalic Acid Series, $C_nH_{2n-2}O_4$.—Oxalic acid, COOH,-COOH, is found in small quantities in the urine as calcium oxalate, and often occurs in excess after the ingestion of rhubarb or cabbage. It is usually increased where the amount of uric acid is increased. It may be obtained in the laboratory along with urea and carbonic acid gas from the oxidation of uric acid, and it is believed to be formed from the latter in the body to some extent. Oxalic acid is a violent poison. It crystallizes from aqueous solutions in large, transparent prisms, which effloresce when exposed to the air.

Succinic acid, $COOH,(CH_2)_2,COOH$, has occasionally been found in the urine after the ingestion of asparagus and other vegetables and fruits. It has also been detected in the sweat, the intestinal contents, and in the thymus and thyroid glands. It forms large colorless crystals which are unaltered by the air and which fuse at 180° C.

Amido Acids are derived from the fatty acids by replacing one or more hydrogen atoms by amidogen, NH_2. They are formed from proteids and albuminoids (gelatin) during digestion and metabolism, and are considered important precursors of urea.

Carbamic acid, OH,CO,NH_2, amidoformic acid, is not known in the free state. Its ammonium salt has been found in the blood and is believed to be an intermediate substance between proteids and urea.

Leucin, $(CH_3)_2,CH,CH_2,CH,NH_2,COOH$, α-amidoisobutylacetic acid, is isomeric with and was formerly considered identical with amidocaproic acid. It is present wherever proteids are being broken up by tryptic digestion, by boiling with dilute acids or by putrefaction. It has been found in certain glands after death, and is found in the urine in acute yellow atrophy of the liver and phosphorus poisoning. There are satisfactory proofs of its being one of the precursors of urea. It crystallizes if pure in shining white plates, but usually forms characteristic round knobs or balls.

Tyrosin, $HO,C_6H_4,C_2H_3,NH_2,COOH$, p-oxyphenylamidopropionic acid, contains a phenyl group, and is consequently a member of the aromatic group of substances as well as an amido acid. It is formed with leucin from the breaking up of proteids in pancreatic digestion, and especially in putrefaction. It crystallizes in colorless, silky, fine needles, which are often grouped into tufts or balls. It has not been definitely proved to be a precursor of urea.

Aspartic acid, $HOOC,C_2H_3,NH_2,COOH$, amidosuccinic acid. It is formed from proteids during pancreatic digestion, and is probably a precursor of urea in the animal body. It crystallizes in rhombic prisms.

Glutamic acid, $HOOC,C_3H_5,NH_2,COOH$, amidopyrotartaric acid. It is formed along with aspartic acid during pancreatic digestion. It crystallizes in rhombic tetrahedra or octahedra or in small leaves.

Lysin, C_6H_{14},N_2O_2, Arginin, C_6H_{14},N_4O_2, and Histidin, C_6H_9,N_3O_2, are probably amido acids, but in their reactions they resemble bases and are grouped together under the name of the hexone bases because they each contain six atoms of carbon. They are among the products of proteid decomposition. Lysatin or lysatinin, which is sometimes given as a separate substance, is probably a mixture of lysin and arginin.

Glycocoll, NH_2,CH_2,COOH, amidoacetic acid, is also known as glycocin or glycin. It is formed from the decomposition of proteids and albuminoids, and is found free in the intestine as a result of the breaking up of the bile salts. It is also set free when hippuric acid is boiled with mineral acids or alkalies.

Sarcosin, NH,CH_3,CH_2,COOH, methyl glycocoll, is not found in the body.

Creatin, $NH,CNH_2,NCH_3,CH_2,COOH+H_2O$, may be prepared synthetically from cyanamide, CN,NH_2, and sarcosin. It occurs among the extractives of muscle and is regarded as a probable precursor of urea. When injected into the blood, however, it loses the elements of water and appears in the urine as creatinin, $C_4H_7N_3O$.

Taurin, NH_2,C_2H_4,SO_2,OH, amidoisethionic acid, is found combined in the bile salts. It may occur free in small quantities in the intestines. It crystallizes in colorless, shining, four to six sided prisms, often of large size.

Bile Acids.—Glycocholic and taurocholic acids are found in the bile combined with soda to form the bile salts. They consist of cholalic acid in combination with glycocoll and taurin respectively.

Glycocholic acid, $C_{26}H_{43}NO_6$, is found in human and ox bile, but is absent or nearly so from that of carnivora.

Taurocholic acid, $C_{26}H_{45}NSO_7$, is found principally in the bile of the carnivora and man, but is also present in oxen, sheep, and goats.

Cholalic acid, $C_{24}H_{40}O_5$, is found combined in the above-named bile acids. It is insoluble in water, but soluble in alcohol, and slightly so in ether. It crystallizes in rhombic prisms or in large rhombic tetrahedra or

octahedra. Choleic acid, $C_{24}H_{40}O_4$, and fellic acid, $C_{23}H_{40}O_4$, are also present in small quantities in human bile, combined in place of cholalic acid in the bile salts.

Aromatic Acids.—Acids of the benzene series. A number of these are present in the body in small quantities. They are derived partly from the aromatic substances contained in the food, and partly from the breaking up of proteids. Tyrosin has been already described under the amido acids. The following are found principally in the urine:

Hippuric acid, $C_6H_5.CO.NH.CH_2.COOH$. Benzoylamidoacetic acid occurs in large quantities in the urine of herbivora, but only in small quantities in the carnivora and man. The quantity in the urine is increased by vegetable food containing benzoic acid compounds, and by putrefactive processes in the intestine. It may be decomposed into benzoic acid and glycocoll.

Ethereal sulphuric acids include the following four acids, phenol-sulphuric acid, $C_6H_5.O.SO_2.OH$, cresol-sulphuric acid, $C_7H_7.O.SO_2.OH$, indoxyl-sulphuric acid or indican, $C_8H_6N.O.SO_2.OH$, and skatoxyl-sulphuric acid, $C_9H_8.N.O.SO_2.OH$.

These acids are all found in the urine, and are derived from the phenol, cresol, indol, and skatol which are formed in the intestines as a result of the putrefaction of proteids. Any circumstances favoring the latter process, such as intestinal diseases accompanied by obstruction, increase the amount of these acids in the urine.

Aromatic oxyacids, of which the principal are paraoxyphenyl-acetic acid, $C_6H_4.OH.CH_2.COOH$, and paraoxyphenyl-propionic acid, $C_6H_4.OH.C_2H_4.COOH$, are formed from tyrosin in small quantities in the intestine and pass unchanged into the urine.

Nucleic Acids.—These are acids rich in phosphorus, of complex and variable composition, found among the most characteristic constituents of cell nuclei. They combine with proteids to form numerous varieties of nuclein and nucleoproteid. Among the products of their decomposition, the most important are the alloxuric bodies, also known as the xanthin or still better as the purin bodies.

Uric Acid.—$C_5H_4N_4O_3$, trioxypurin, is found in adult human urine to the extent of from seven to ten grains per day, combined with bases to form urates. In birds and reptiles it replaces urea in the urine as the principal end product of proteid metabolism. In man it is derived principally from the nuclei of broken-down cells and from the purin bodies contained in the food. The extent to which it is formed from proteids in the body cannot be considered settled. For further details about uric acid, see the articles on *Gout* and *Urine*.

Wesley Mills.
William S. Morrow.

ACIDS, MINERAL, TOXICOLOGY OF.—The only mineral acids which require extended consideration at the hands of the toxicologist or physician are sulphuric, nitric, and hydrochloric acids.

I. *Sulphuric Acid.*—A number of different forms of sulphuric acid occur in commerce.

First, the pure acid, colorless and oily, known as *chemically pure sulphuric acid*, having a specific gravity of 1.842, and containing about 99 per cent. of sulphuric acid.

Second, a solution of much the same appearance containing 92.5 per cent. of sulphuric acid, the *Acidum sulphuricum* of the United States Pharmacopœia.

Third, the dilute, watery solution of the acid also clear and colorless, containing 10 per cent. of sulphuric acid, the *Acidum sulphuricum dilutum* of the United States Pharmacopœia.

Fourth, the *commercial acid* of varying strength, and colored brown to black by organic impurities.

The concentrated acid in all its forms is intensely corrosive, destroying readily any organic tissue with which it may come in contact. Its power in this direction is due to its avidity of water, it being able to extract the elements of water from wood, cloth, or flesh, leaving the residue charred and more or less blackened as a result.

On clothing, if dark colored, the acid produces a brown stain with red edges, and after a time decomposes and softens the fibres of the cloth, so that it easily falls to pieces. The acid spot is always wet, due to absorption of water from the material and from the air. On light-colored cloth the acid produces a brown stain, which after a time turns black and destroys the tissue of the cloth.

Wood is blackened by the action of the acid, and at the same time softened and disintegrated. In damp weather the stain of this acid on wood is moist, unless the acid has been neutralized by an alkali.

On the skin the concentrated acid produces an intense, biting sensation, and soon blisters and destroys the cuticle, and to a greater or less extent corrodes the tissues underneath. If the acid is not removed at once, the spot turns brown; and even when it is washed away immediately, or its action neutralized by alkalies, the cuticle is destroyed and a red scar remains wherever the acid has acted. This acid, because it is so readily obtained, is the favorite of the acid thrower, who attempts to disfigure or blind his victim by throwing the fiery liquid over the face and person. A number of cases are reported yearly in which such attempts have been more or less successful. If the acid gets into the eyes, its corrosive action and the intense inflammation it sets up are almost sure seriously to impair the sight, and certainly to cause the most excruciating suffering.

Fatal results from sulphuric acid introduced into the body are numerous. Yet the acid has never been used in homicidal cases except when the intended victim has been incapable through age or condition of resisting the administration of the acid. For so intensely sour is its taste, and so suddenly corrosive its action, that in the very act of taking it, it is rejected. The results of taking it are therefore to be looked for in cases of suicide or accident. A number of such cases are reported, and some in which there has occurred a curious lack of early symptoms, the action of the acid seeming to be delayed by the presence of food in the stomach. Some cases are reported in which the acid has been taken by the vagina or rectum. In all these instances the corrosive action of the acid has been in evidence sooner or later.

When the concentrated acid is swallowed, there is at once the most intense pain in the mouth and throat. In many instances this sense of pain is so excruciating as to deprive the person of the power of motion, yet cases are recorded in which, after taking it, the person has walked or ridden a considerable distance. The pain quickly extends to the stomach, and there is continued vomiting of a thick, brown material, strongly acid and tinged with blood. The mouth becomes filled with a tough, stringy mucus, so that difficulty of swallowing and loss of speech speedily occur. The mouth and the tongue are greatly swollen and, at times, as though smeared with white paint, though after a time the color changes to gray or brown. The abdomen is very painful when touched, and is generally distended. All food is immediately rejected by the stomach and vomiting is usually incessant. The face is pale and anxious, the pulse is quick and feeble, the body cold and covered with a cold perspiration. There is no delirium. The bowels are constipated; the stools if any, are more or less black and contain shreds of lining membrane. Death usually occurs within from eighteen to forty eight hours, though it may occur from the secondary effects of the acid many months after the latter has been taken.

The treatment consists in the administration of dilute alkalies, by preference calcined magnesia, though in an emergency washing soda or even the plaster from the wall may be used to neutralize the acid and in case of the lack of all these, water should be given copiously. Mucilaginous and oily drinks should also be administered to aid in recovering the corroded surfaces. The stomach pump should not be used on account of the softened condition of the tissues. In cases of impending suffocation, which sometimes occurs from the swollen condition of the glottis or from the presence of a mass of stringy mucus, tracheotomy must be resorted to.

A post-mortem examination of a case, rapidly fatal, shows the mouth and tongue more or less corroded and covered with a white or brown coat, the œsophagus corroded and at times its lining membrane loosened entire in the form of a tube, or more commonly detached in shreds. The bronchial tubes are intensely inflamed. In some instances death has resulted from the effects of the acid on the organs of respiration alone. The stomach is intensely reddened, and its mucous surface may be brown, the blood-vessels beneath showing as dark lines through the action of the acid on the blood. Sometimes the stomach is perforated, the edges of the perforation being black and jagged, and the surrounding organs showing marks of inflammation. In cases of death from the remote effects of the acid, the appearance of the body is that of starvation. The glands of the stomach are found to be extensively destroyed and the stomach itself much contracted. Constriction of the stomach and œsophagus has also been found on post-mortem examination.

Recovery has taken place from so large a dose as three ounces, and death has resulted from forty drops, in the case of a child. The amount which will cause death depends so much on individual conditions that it is impossible to state what may be considered a fatal dose. Recovery from a case of sulphuric acid poisoning is not usual, though a number of cases of recovery have been reported.

The search for sulphuric acid in a case of death by its action may lead to negative results, as has been shown in a number of cases. This comes from the fact that most, if not all, of the acid is gotten rid of by the incessant vomiting, by its neutralization by the remedies administered, by its combination with the albuminous matters of the tissues, or by its elimination by the kidneys or bowels. In order to detect the acid, the vomited material or the stomach with its contents must be steeped in water for some time, the solution filtered, and the reaction of the filtrate tested with blue litmus paper. A slightly acid reaction is to be expected, even if no sulphuric acid is present, owing to the naturally occurring free hydrochloric acid in the gastric juice.

A portion of the filtrate is to be carefully evaporated to small bulk, and in it is to be placed a lump of white sugar If any sulphuric acid is present, the sugar after a time will turn brown or black, according to the amount of acid present. If to a portion of the clear filtrate, made acid with hydrochloric acid, there is added a solution of barium chloride, a dense white precipitate of barium chloride, insoluble in acids and alkalies, is formed at once, if sulphuric acid be present. The same precipitate will be formed whether free or combined sulphuric acid be present, and care must be taken not to base an opinion on the result of this test, unless it can be proven that the amount of barium chloride is in excess of that which would be present in the foods taken, or would correspond to a greater amount than that in any medicine administered. The quantity of sulphuric acid is readily calculated by collecting and washing the barium sulphate formed, and igniting it with the filter paper in a porcelain crucible, and then weighing the product after the crucible has become cold. Each 100 parts of the precipitate correspond to 42.06 parts of anhydrous sulphuric acid.

II. *Nitric Acid.*—Nitric acid or aqua fortis is not so common as sulphuric acid, and for this reason, and also because of its warning odor, it is not so liable as the other to be taken accidentally. A number of cases of suicide and some cases of accidental death have been traced to its use. Fatal results have followed both when the fumes have been inhaled and when the acid itself has been swallowed.

A number of forms of the acid occur.

First, a clear, colorless liquid having a specific gravity of 1.42, and containing 75 per cent. of the acid. This liquid fumes strongly in the air, and its vapor is suffocating.

Second, a colorless liquid having a specific gravity of 1.414, and containing 68 per cent. of the acid. This is the *Acidum nitricum* of the United States Pharmacopœia.

Third, a dilute acid, also clear and colorless, containing 10 per cent. of the real acid, the *Acidum nitricum dilutum* of the United States Pharmacopœia.

Fourth, a commercial acid of varying strength, yellow or brownish red in color and giving off irritating fumes.

All the colorless forms of the acid are decomposed by air and light, with the formation of oxides of nitrogen, and the liquids become colored through the solution of these oxides in the acid. In bottles partly full of nitric acid, the space above the liquid is also filled with the gaseous products of the decomposition of the acid.

The corrosive effects of nitric acid are much like those of sulphuric acid, with the differences that nitric acid has not so great an attraction for water and that it possesses the power to oxidize most organic substances with which it comes in contact. Further, it combines with albuminous substances, making a comparatively stable, yellow compound.

The vapor when inhaled produces a sense of suffocation and fulness in the head which is followed by a cough and by inflammation. These symptoms gradually pass away in most instances, though some cases are recorded in which death has followed the inhalation of the vapor of the acid.

When swallowed in concentrated form, there is at once an intensely severe, burning pain in the mouth and throat which extends soon to the stomach. The stomach is distended and there are eructations of a peculiar, sour-smelling gas. Vomiting usually occurs, the matters vomited being brown in color and generally containing dark brown blood. The mouth is filled with thick mucus and there is often almost complete loss of voice. Swallowing is intensely painful and often impossible. The process of breathing is interfered with on account of the swelling of the glottis and adjacent parts. Sometimes tracheotomy is necessary. The pulse is faint, quick, and irregular. The surface of the body is covered with a cold sweat, and there are frequent chills. The bowels are constipated, and in some cases the urine is suppressed. Toward the end, a stupor sometimes comes on, but the mind is generally clear. Death has taken place in an hour and a half from the primary effects, and from the secondary effects, after two years. Death is usually delayed from twelve to twenty-four hours.

The treatment consists in giving mild alkalies or alkaline carbonates to neutralize the corrosive effects; milk and mucilaginous drinks are also beneficial.

The quantity necessary to produce a fatal result varies, as in the case of the other mineral acids, according to many circumstances. Death has followed the swallowing of two drachms, and recovery has taken place after half an ounce has been swallowed.

The post-mortem appearances, when death has occurred within a short time after taking the acid, show a yellow or brown color on the mouth and lips, and the skin, where the acid may have fallen, is burned and easily detached. A yellowish or brownish, frothy liquid issues from the nose and mouth. The abdomen is usually distended, the membranes of the mouth are white or slightly yellow, the teeth are corroded, and sometimes there are yellowish stains at the junction of the teeth and gums. Marks of inflammation are present in the larynx also. The lining membrane of the œsophagus is softened and often easily detached in long strips. The lungs are congested. The stomach is inflamed and shows yellowish or brown patches or streaks. The muscular coats of the stomach are generally softened, but the organ is seldom perforated. The inflammation gradually decreases in intensity from the stomach downward, and the small intestines show only slight marks of the acid. In prolonged cases there are noted great contraction and marks of ulceration in the œsophagus and stomach. In some cases the stomach has been found with large scars, or almost obliterated, or attached to adjacent organs, with its cardiac and pyloric openings contracted to a mere thread. The body is emaciated, the person having died from starvation—a view which is borne out by the condition of the stomach and organs.

In case the patient has long survived, there is no use

to search in the dead body for indications of the acid. The most promising material for such investigation is, of course, the vomited matter, but if this be not available, the stomach and its contents, if any, may reveal the presence of the acid, provided death has followed the ingestion of the acid within a few hours.

In order to make the necessary tests for the presence of the acid, the materials at hand are treated with water at a gentle heat for some time. The mixture is then filtered and evaporated to small volume. Portions of the solution are then tested as follows:

First, test the reaction of the material with blue litmus. If the litmus is reddened, it shows the presence of an acid, which in this case may be nitric acid, hydrochloric acid, or lactic acid, or an acid salt.

Second, to a crystal of brucine in a porcelain dish add a small amount of the solution and warm. If free nitric acid is present, the crystal turns red.

Third, to a saturated solution of ferrous sulphate, add in a test tube a little of the suspected solution carefully, so as not to mix the two liquids. In a short time a brown or brownish-black line appears at the junction of the two liquids, if nitric acid is present. If alkalies have been administered, concentrated sulphuric acid must be added to the portion of the liquid used for this test, the mixture cooled, and the iron solution poured on this mixture.

Fourth, to a portion of the solution, hydrochloric acid is added, and a fragment of gold leaf. The solution is then carefully heated. If nitric acid is present, a part of the gold, at least, will dissolve. The presence of the gold in solution may be proven by treating the liquid after filtration with stannous chloride, when in the presence of gold a purple coloration results.

Fifth, a portion of the liquid evaporated to small bulk is placed in a flask and to it is added some concentrated sulphuric acid. A strip of bibulous paper that has been dipped in boiled starch containing a little dissolved potassium iodide is suspended from a cork fitted to the mouth of the flask. After a time the paper is turned blue in the presence of nitric acid.

III. *Hydrochloric Acid.*—Hydrochloric or muriatic acid occurs in commerce in several forms:—

First, as a clear, colorless liquid that fumes strongly in the air, giving off suffocating vapors and absorbing water. The solution has a specific gravity of 1.20, and contains 40.8 per cent. of acid.

Second, as a clear solution, having a specific gravity of 1.16, and containing 31.9 per cent. of acid.

Third, as a clear liquid prepared from the preceding by dilution, and containing 10 per cent. of hydrochloric acid.

Fourth, as a yellow liquid containing a variable amount of the acid and colored yellow by iron. This acid also contains traces of arsenic and other impurities.

As in the case of the other acids, hydrochloric acid occasions serious consequences because of its corrosive nature, and is less active in proportion to its dilution. It is, however, the least corrosive of the common mineral acids, and, on account of the irrespirable gas given off, the concentrated acid is less liable than the others to be taken by accident or to be administered in homicidal cases.

When the strong acid is swallowed there is at once intense pain in the mouth, throat, and stomach, followed by vomiting with eructations of gas. In some cases a white vapor is also seen escaping from the mouth. The vomited matters have a strongly acid reaction, and are brown in color and sometimes streaked with blood. The pulse is feeble and quick, the breathing labored, and the surface of the body is cold and covered with perspiration. The mouth and throat appear white and swollen.

The treatment in cases of hydrochloric acid poisoning consists in the administration of dilute alkalies and mucilaginous and oily drinks. The carbonates are not to be used except as a last resort, on account of the softened condition of the stomach.

Recovery has occurred from a large dose of the acid, and death has followed the taking of a small one. The amount necessarily fatal is unknown, the result depending more on bodily conditions and treatment than on the amount of the acid.

If the case proceeds rapidly to a fatal termination, the appearances at the post-mortem are generally as follows: The mouth, tongue, and throat are white and swollen, the epiglottis much enlarged, the œsophagus devoid of its lining membrane to a greater or less extent, or thrown into longitudinal folds and thickened. The lungs are inflamed and somewhat congested. The stomach shows the corrosive effects of the acid; its walls are much softened and sometimes present a charred appearance. The intestines also show marks of inflammation.

The detection of the acid, except in the materials first vomited, is extremely difficult, and complicated by the fact that there are present in the body normally a varying amount of chlorides and even of free hydrochloric acid. Tests of the material supposed to contain the acid are made by treating it with water for a considerable time and filtering the liquid. A portion of the filtrate is treated in a porcelain dish with a few drops of phloroglucin vanillin solution, made by dissolving 2 gm. of phloroglucin and 1 gm. vanillin in 30 c.c. of alcohol. On careful evaporation, a red line appears at the junction of the liquid and the dish.

The filtrate turns blue litmus red.

The concentrated liquid causes white fumes, if a glass rod dipped in concentrated ammonium hydrate be held near it.

A portion of the filtrate added to a solution of silver nitrate gives a white curdy precipitate, insoluble in acids, but readily soluble in ammonium hydrate. Hydrochloric acid, free or combined, gives this reaction, and the above test is of use only in case the amount of the precipitate is largely in excess of what might be due to the chlorides in foods and in the gastric juice. The above precipitate also furnishes a ready means of estimating the amount of the hydrochloric acid present, if the precipitate is carefully dried at 100° C. and weighed, each hundred parts corresponding to 25.43 parts of anhydrous hydrochloric acid. *Herbert M. Hill.*

ACIDS, THERAPEUTIC ACTION OF.—In treating of the therapeutic action of acids, reference is directed to the stronger acids which possess all the chemical characters of this group in a marked degree. The most important are sulphuric, nitric, hydrochloric, phosphoric, acetic, citric, and tartaric acids. Of the vast host of other acids, represented by boric, benzoic, oleic, carbolic, salicylic acid, etc., the chemical characters of the true acid are either absent or gradually diminish until they are overshadowed by other important therapeutic properties.

When applied to the tissues, the local effect varies from the powerful corrosive action of sulphuric acid to the mild irritation of the vegetable acids. Sulphuric acid is destructive to all tissues, altering and destroying them beyond recognition. It is extremely hygroscopic, and this affinity for water is the cause of its great penetrating and diffused action. It combines with the albumin, fibrin, etc., producing a jelly-like mass which may be partially discolored and charred. The milder solutions simply coagulate and disorganize the albuminous structures. Nitric acid acts similarly, but is less severe. In addition to its corrosive effects, it produces a characteristic yellowish stain, which serves to distinguish it from other acids. A somewhat similar stain is caused by bromine and iodine, but marks of either of these are readily removed by a little caustic potash, while the nitric acid stain becomes of a brighter hue by the action of the alkali. Hydrochloric acid is very much weaker. It does not cause the same destruction of tissue as the other two acids, but the parts become white or whitish brown by its coagulation of the albumin; at times bullæ and blisters may form. On the soft mucous surfaces, the strong acid may produce a swollen; structureless mass. The other acids, with the exception of glacial acetic acid, are simple irritants.

When the acids are administered internally, the local effects are the same as when they are applied to the skin, but more severe on account of the greater delicacy of the tissues. In addition to the action upon the mucous membrane, they also act upon the secretions and upon the contents of the stomach. In medicinal doses, the beneficial effects of dilute acids are marked, but how far this is due to their local action or is secondary to action after absorption, is still an unsettled question. After absorption they lose their acid character, they combine with the alkaline bases in the blood, and render it less alkaline, but never produce acidity. They are excreted as sulphates, chlorides, etc. The presence of hydrochloric acid in the gastric juice is regarded as a true secretion of the gastric glands. As escharotics, acids are a useful adjunct to the therapeutic armamentarium. Sulphuric acid is not so much employed as it was formerly, when it was a favorite reagent for removing morbid growths. Its painful effects and great penetrating power are objectionable, and it is replaced by other caustics which are more easily controlled. This penetrating property, however, renders it, as well as nitric acid, of value in bites and wounds of poisonous animals. Nitric acid is always selected when any destruction of tissue is desired. Its value in syphilitic sores and phagedenic ulceration is well recognized. It removes the necrosed tissue and produces a healthy growth of granulations. Chromic acid and carbolic acid may be mentioned here. They are not true acids, but their caustic properties are frequently resorted to. Their action is more easily controlled, but, in the case of chromic acid in particular, evil effects may follow its absorption. Hydrochloric acid is seldom used, although it was at one time often employed to destroy the membrane in diphtheritic throats. The use of acetic acid is almost limited to the slow removal of warty growths and the treatment of ring-worms.

In weak solutions the acids become stimulating and disinfecting lotions. Nitric acid has been found of service in indolent ulcers and wounds, and in cystitis. Hydrochloric acid is employed for the same purpose in the anginas of scarlet fever and diphtheria. In very dilute solutions all acids possess a cooling and refreshing action when applied to the surface of the body; they also exert an astringent effect upon the blood-vessels and sweat glands, as when employed to prevent or lessen the night sweats of phthisis. Nitromuriatic acid baths and compresses have been extolled as a means of relieving the hepatitis of hot climates.

When administered as a beverage all acids are most refreshing. This is well known in all tropical countries. Lemonade, lime juice, dilute phosphoric, acetic, citric, and tartaric acids are universally employed. Their effervescing salts are particularly useful. The treatment of fevers by the continuous employment of acids has many disciples. They prove refrigerant and disinfectant, promote digestion, and if there is any diarrhœal tendency, their astringent properties become of service. The vegetable acids, either pure or in combination, have a more relaxing effect and promote excretion by the emunctories.

Beaumont Small.

ACNE.—DEFINITION.—Acne may be defined as a disease of the sebaceous glands of the skin and of the follicles of the lanugo hairs attached to them, thus being both a folliculitis and a perifolliculitis. It is characterized by their inflammation and suppuration, and often by their destruction, with a resulting scar.

The term acne has been qualified in accordance with various salient features presented by its lesions or with certain clinical characteristics predominant in a case, and there are therefore found in literature such terms as acne vulgaris, pustulosa, punctata, juvenilis, adolescentium, etc. All, however, represent the same process. In addition to these, the name acne has also been applied to a large number of affections, which have nothing whatever in common with true acne, but which represent totally different pathological entities, and among these are included tuberculous affections, drug eruptions (iodine and bromine acne), or folliculitides of artificial origin (tar, oils, and grease, etc). For the sake of simplicity and definiteness, the disease will be treated of here under the heading of acne simplex—the more superficial form—and of acne indurata—the deeper-seated variety. Acne rosacea, being a compound process, will receive separate mention.

SYMPTOMATOLOGY. — *Acne Simplex.* — Acne simplex possibly represents the most common form of the disease, as it is the one developing particularly about the age of puberty and in young people. Instances have also been seen at a much earlier age, and likewise later in life, about the climacteric. Apparently, it occurs more often in the female than in the male sex, but the ratio between them is probably more relative than exact. The lesions characterizing the affection occur without regularity or symmetry, though they are usually distributed bilaterally. Still, variations are met with, such as one side of the face being intensely attacked, and the other side only silghtly, and sometimes it is found unilateral. Acne occurs on the face especially, but it also often appears on the chest and shoulders, and sometimes on the upper arms, or it extends down the back even to the thighs.

The lesions characterizing acne simplex are, comedones, papules, and pustules. In this variety of the disease, the comedo, or popularly the blackhead, as a rule constitutes a central point around which the inflammatory changes take place. These can usually be seen and traced in every case, and consist of redness around the comedo, then formation of a papule, and lastly transformation into a pustule. Lesions may, however, arise independently of the comedo. The lesion having become pustular, remains as such for a few days; the redness then begins to fade and a crust forms, which falls off in the course of a few days or more, leaving a slight stain, or a scar, or a pitting. The pustular transformation does not, however, take place in all of the lesions. Many of them having reached the papular stage, remain in that form for a variable length of time and then gradually undergo involution. Neither do all the comedones become implicated and result in papules or pustules, but many persist *in situ* unchanged. In consequence, on an affected surface all stages of the disease are usually met with, and

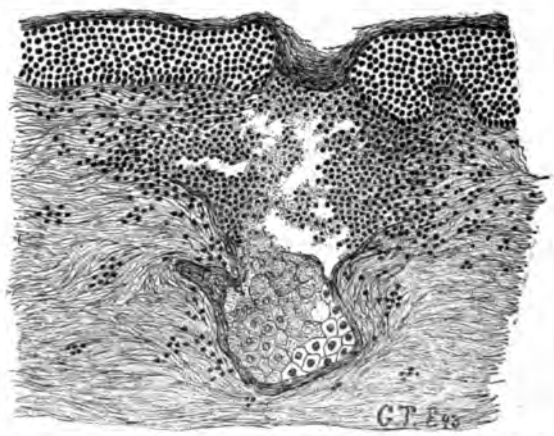

FIG. 12.—Section through a Superficial Acne Lesion (Acne Simplex). (Author's drawing.)

comedones, papules, pustules, crusts, stains, and scars are seen more or less aggregated together without order or regularity, the whole constituting the condition known under the name of "pimply skin" or "pimples."

The lesions of acne simplex present no especial subjective symptoms, though when handled the inflamed ones are sometimes slightly painful. Occasionally a burning sensation or itching is complained of.

The scars and stains resulting from the lesions vary in degree, in number, and in size. In many cases, no scars are produced and the subsidence of the inflammatory

ACNE SIMPLEX, SHOWING COMEDONES, PAPULES AND PUSTULES.

(FROM THE COLLECTION OF PHOTOGRAPHS OF DR. GEORGE HENRY FOX.)

Pathological Anatomy.—According to many writers, the starting point of the inflammatory change is around the follicle of the lanugo hair attached to the gland, the latter becoming only secondarily implicated in the process. The writer has, however, frequently found the hair follicle absolutely intact and not concerned in the pustular formation. The inflammatory changes always begin around the follicle—that is, it is primarily a perifolliculitis. The tissues are infiltrated with round cells, which are located at first around the network of blood-vessels supplying the sebaceous gland attacked. Unna states that the infiltration consists of palsma, large fusiform "mast" and a few giant cells, leucocytes being found only when suppuration has occurred. The degree of infiltration varies in different lesions and cases. The writer has found that in acne simplex lesions, infiltration is more superficial and located about the duct and upper part of the gland, while in the indurate form it is deeper and around the body of the gland especially. It may also extend widely throughout the cutis; and several contiguous glands becoming affected, they melt together into one inflammatory and suppurating area. The perifollicular inflammation having extended to the gland, its parenchyma becomes infiltrated, its cavity is distended, and its walls rupture in places. Its contents are then composed of sero-fibrinous fluid, sebaceous débris and leucocytes, some intact glandular epithelium, and often the comedo. In acne simplex the gland is not always destroyed, but in acne indurata it generally is. The same changes may affect the follicle of the lanugo hair attached to the gland.

Etiology.—The etiological causes active in the production of acne, whether of the simple or indurate variety, are manifold, and the process cannot in any sense of the term be regarded as of specific origin. Whether the many disturbances or systemic conditions found in connection with these cases are to be estimated as of causative importance, or as simply of predisposing effect, is a question which will be determined when the pathological origin of the disease is absolutely established. Until then, it can only be said that without their proper valuation and consideration, no case of acne can be understood or its needs correctly estimated, for it is more upon these etiological factors that treatment should be based than upon any other feature presented by the process. Age plays an important part, as the inception of the disease in the large majority of cases is at or about the time of puberty. Still it occurs at other ages, and the writer has seen it develop at every period of life between puberty and the climacteric, and even later. In youth, acne simplex is most common, but acne indurata occurs most frequently after twenty-five. That it tends to disappear at the age of twenty-one—a belief so current among the laity and unfortunately the general medical profession also—is an unwarranted assumption, due to the fact that many patients have at that age recovered from one or another disturbance of nutrition incident to their development, and occurring during the period in which stability of their tissues was in a stage of transition; that is, major etiological causes of the disease had by that time been removed by nature, by general treatment for other systemic conditions, or by greater care of the functional and general health on the part of the individual afflicted, through education and possibly observation of the relation existing between the eruption and some deviation from normal health.

Menstrual and uterine disorders are frequently accused as predisposing factors in the production of acne, but still too much stress should not be laid upon them alone, since the cause of the menstrual disturbance may more properly be the important factor. At any rate, an aggravation of an existing acne will commonly occur before, during, or after a menstrual epoch. And yet the abnormal conditions which affect this function may be entirely removed, but the eruption will persist; or the acne may be radically cured, while the functional or other disturbance of the uterine organs remains unchanged. In association with the process, all other forms of functional and nutritive disturbance are also met with. Constipation is very frequent and not uncommonly chronic catarrhal forms of diarrhœa. Chlorosis or anæmia of variable grades and debility of various origin are often the basic factors. Gastric and intestinal dyspepsia are common, though in my experience it is most usually fermentative intestinal indigestion which is of importance. Dilatation of the stomach has been stated to be particularly common in these cases, but it is undoubtedly exceptional. Mental and physical exhaustion, excesses of any and every kind, masturbation, urethral irritation, a sedentary life, excessive exercise, the gouty, rheumatic, or strumous constitution, all must be mentioned as causes of acne in themselves or through their influence upon the systemic health. But if analysis is applied to all of these, it cannot but be evident that the whole may be comprised in the category of lowered or debased nutrition, as all are productive of more or less marked nutritive disturbance of the organism. In consequence, the etiology of acne can be briefly stated to depend especially upon some disturbance occurring in the functional or systemic health of an individual, which results in disordered or lowered nutrition. External and local causes, however, also play a certain part in the production of the disease. Among these, there may be mentioned exposure to cold winds, to irritation of various kinds, inattention to cleanliness, etc. The face, the locality most generally affected, is that surface especially and constantly exposed to such factors as changes of temperature, to dust and dirt of every description carried by the winds, to irritating influences of many kinds; and the fact that it is attacked so disproportionately in frequence to other surfaces equally or almost as rich in sebaceous glands would suggest that these various external agents and causes have an influence in developing or at least in aggravating many, if not all, cases of the disease.

As particular causes of acne, the atrophic form of rhinitis has been mentioned, and recently a German colleague has claimed that all cases of the process owe their origin primarily to some slight or severe ulcerative or erosive process in the nasal cavities, which allows entrance of pyogenic germs into the lymphatic circulation.

The acne due to the use of iodine and bromine compounds has as its direct inducing cause one of those substances, and is a drug eruption; not an acne in a strict sense, but one of artificial origin. The same may be stated in regard to the folliculitis due to the closure of the follicle by tar—after use of a tar ointment—and known as acne picea; while the many other processes dubbed acne of one kind or other, having nothing in common etiologically with acne simplex and indurata, should all be strictly disassociated from these.

The effect of diet upon the disease is of some importance, since it may originate the process, through the functional disturbances which it may create, or it may aggravate an already existing acne. Among the articles of diet which may be particularly mentioned are sweets of all kinds, pastries, oatmeal, cheese, nuts, highly seasoned and rich foods, shellfish, etc. Milk in certain individuals appears to have the effect of causing an outbreak of lesions; so also has cream, fermented drinks, such as beer, etc., champagne and syrups with soda or natural waters.

Diagnosis.—There should be no difficulty in making the diagnosis of a case of acne. Popularly known as "pimples" or a "pimply face" or an attack of "black-heads," it is so common that its recognition should be immediate. Especially is this the case with acne simplex, in which the comedo plays so important a rôle; but acne indurata may at times offer some points of doubt. The papular form of eczema may be differentiated by its occurrence on the extremities as well as on the face, and it is never limited to the latter. Its lesions are smaller, often crowned with a minute vesicle, and they tend to coalesce into patches; they are very itchy, and when opened do not contain sebaceous débris. The vesicular or pustular elevation is superficial and results in the formation of epidermic scales and small exudation crusts. The pustular syphilide may be mistaken for acne, and vice versa;

and so much is this the case that one form of syphilitic eruption has been named acneiform. These lesions may be limited to the face, but they are more often coincident with syphilitic manifestations on other parts of the body or on the mucous membranes. They tend to form groups, to dry and become covered with crusts; and when these are removed, a punched-out ulceration filled with seropurulent fluid and bounded by a more or less infiltrated wall is found. Many mistakes in diagnosis are made between an indurate acne and the superficial gummatous syphilide—the so-called tubercular syphilide—especially when the latter is situated on the nose. But the error should not occur when it is borne in mind that the syphilide as a rule is circumscribed in its occurrence, its lesions are grouped, indolent, undergo softening and crust formation, and beneath the latter ulceration occurs. The process very usually extends slowly in an excentric or serpiginous manner, leaving more or less marked cicatrices. Acne indurata, on the other hand, runs a more acute course, is painful and furuncular in aspect, occurs here and there without reference to pre-existing lesions, does not tend to form groups, heals up rapidly after evacuation, does not ulcerate nor tend to progress in a serpiginous manner, and frequently leaves no scar, or at the most one superficial and ill defined.

There is a papular form of erythema occurring at the menstrual epoch in women which is very usually confounded with acne. It is papular in character, though occasionally a pustule occurs. It appears on the face especially, but sometimes over the neck and shoulders. Its appearance is brusk, a few days before, during, or just after the menstrual epoch. It may consist of a few or of many lesions, which are frankly inflammatory and about the size of a small pea. They do not contain any comedo nor sebaceous matter; they itch and burn, persist for a few days to a week, and then subside, to reappear, however, at the time of the next period. This eruption, purely a reflex papular erythema, is usually regarded as an acne, but it should be strictly separated from it.

PROGNOSIS.—The prognosis of an acne is favorable, and it can be said that all cases of the disease are curable, provided that the etiological factors existing in any given case are correctly estimated, and that the therapeutic efforts are carried out carefully and systematically by the patient. Acne also may and does disappear spontaneously, but that is the case when the one or other cause of the process has also been removed by course of time, improvement of general somatic conditions, etc.; but in view of the disfigurement, scarring, and changes which may occur in the skin from the disease, it is not advisable to wait for a spontaneous involution and to leave the patient without such proper care as will keep the process within bounds or gradually cause its entire cessation. In giving to a patient the prognosis of his or her acne, it should also be borne in mind that the same causes can produce the same effects, and that the complete or lasting cure of the eruption will therefore depend upon the individual's avoidance of the particular cause or causes or factors which have been found to be the basis for the existence of the disease in any given case. As to the length of time needed to cure a case, definite statements should not be made, since the duration of treatment will have to depend upon the response of the patient to the remedial agents made use of, the care and system with which the orders of the physician are carried out, the age of the patient, and particularly upon the possibility of removing the etiological cause or causes. Still, if not absolutely cured, no case should be dismissed as incurable, as all can be very materially benefited by proper care.

TREATMENT.—The methods, procedures, and remedies pertaining to the treatment of acne are manifold and various, being such as have to do with the general systemic health, and such as are local and applicable to the lesions themselves. In no sense of the term is there any specific medication in vogue or any drugs which can be regarded as specific, but every case has to receive such treatment as is indicated by the conditions found to exist. The statement just made refers especially to the internal and general systemic care, and in these particulars there is no disease in which, as it may be put, "individualization" of treatment is so necessary and called for. As a rule, no two cases can be treated alike, but each must receive such special advice as may be judged to be required, after a thorough investigation into the bodily and functional health of the patient, his habits, mode of life, diet, etc. Under these circumstances, should constipation be the factor in the case, it should be relieved by cascara sagrada, aloin, or some other remedy affecting the bowels, or by means of diet, proper exercise, cold douches, etc. Gastric or intestinal indigestion, fermentative processes, should be appropriately combated by dietary measures, the mineral acids, pepsin, etc., or by intestinal antiseptics—resorcin, sulphocarbolate of soda, salicin, charcoal, etc., and by such other measures as are indicated for these conditions. If debility or anæmia exists, then tonics are called for: iron, nux vomica, mercury, the vegetable bitters, feeding up, general hygienic methods, etc. The ferrum reductum, the carbonate, and the dry sulphate of iron have proved the best in my experience; hæmogalloi is particularly good when the stomach rebels against the other forms or when constipation exists. Except to tuberculous subjects, the iodide of iron should not be given, owing to the possibility of the iodine causing an eruption. When administering iron in cases of acne, the blood should be tested at the beginning of its use for its percentage of hæmoglobin, and retested every two to three weeks. Only in this way can certainty be had that the iron given is being assimilated and the blood state is or is not improving. Practically, Fleischl's hæmometer answers all requirements for testing. For strumous subjects, cod-liver oil, the hypophosphites, and the malt preparations are especially valuable. If, on the other hand, the acne occurs in gouty subjects, in those who are rheumatic or plethoric, who show evidences of deficient elimination, then alkaline mixtures, the potash salts—except the iodide and bromide—iithia, saline purgatives, colchicum, the salicylates, strict regimen, etc., are of the greatest service. In other words, every indication obtained from investigation of the patient's history should be duly estimated and receive such attention as it requires. It is useless to take up each seriatim, but all should be considered together in order to obtain as rapid progress as possible. The effects of calcium sulphide are illusory: none when given alone; but when exhibited together with dietary regulations, with other internal and local treatment, then improvement is seen in the case. But the result is obtained by those same measures when no calcium sulphide is administered. Arsenic is of use under certain conditions, but should not be regarded as a specific. As a rule, more harm than benefit is done by it. It is of value in certain cases in which anæmia or debility is present. In acute examples of the disease it is contraindicated, but it may be of benefit in those which are chronic in type. In those acnes which are complicated by a seborrhœa oleosa, or in which the process is sluggish and the lesions are indolent and leave congested stains, ichthyol internally is frequently of value. Beginning with five-grain doses three times a day, the amount may gradually be increased until gr. xv. ter in die are being taken. The drug is harmless, and for its best effects should be continued for several months. The question of diet is of some importance, but yet it should not be carried to an extreme, nor be regarded as the keynote of the treatment. In general, it may be stated that the diet should be composed of nutritious and easily digested food, and the various articles chosen or forbidden should depend to the greatest extent upon the digestive conditions in existence in the individual case under care. As a rule, I have found that it is advisable to forbid in all cases such articles as are comprised under the heading of sweets—desserts, candies, jams, preserves, pies, rich puddings, etc.—and also oatmeal, cheese, and nuts. Besides these, the diet should exclude stimulating, highly seasoned, and indigestible foods of all

kinds. Oysters are allowable, but lobsters and crabs will be found injurious. Clear soups, plainly cooked fish, roast and broiled and boiled meats, poultry and game, vegetables of all kinds, salads with plain vinegar and oil dressing are perfectly allowable for all cases, but at the same time the diet in these as well as in all particulars will have to be varied according to the necessities of the individual case. It may thus be found that in one milk, cream, butter, and fats will be beneficial, while in others they will be injurious; in some, a light claret or Rhine wine with the meals is distinctly beneficial, but in others all wines will be harmful. The same remarks are pertinent as regards beer, alcohol, tea and coffee; and on the whole, it may be stated that so far as diet is concerned, the same rule should be followed as has been laid down for the internal medication of acne—that is, it should be made to conform to the needs and the requirements of the individual afflicted, and not with a view of furnishing a specific regimen which shall of itself remove the affliction.

General hygienic laws should also be enforced. Exercise in moderation, but not. however, to the excessive point it is carried to-day, is of value, and so also is a change from a sedentary to an active life. Attention to personal cleanliness, to bathing, to early hours is clearly indicated, and dissipation and excesses of all kinds should be avoided.

The *local treatment* of acne is of equal importance with the internal and with the general care of the patient, for by these means the lesions of the disease can be removed and a healthy action of the skin can be brought about, and that even before the predisposing causes have been entirely disposed of. Many cases, moreover, can be cured by external treatment alone, but the writer has failed so far to obtain such a result from exclusively internal care. Both, in reality, should go hand-in-hand in order to get the best and most rapid cure of the process.

The first requisite in the local treatment is the use of soap and water. The surface of the skin, the seat of an acne, should be thoroughly washed night and morning. Any good toilet soap is all that is necessary; but a marble or sand soap has been recommended, as well as the Tr. saponis viridis. Superfatted soaps containing resorcin, ichthyol, sulphur, or mercuric chloride are also advised and used, but unless left on the surface over night, for instance, they offer little advantage over a plain, pure soap. Tar soaps are decidedly injurious in these cases, particularly if rubbed into and left on the skin, inasmuch as the tar may lead to the development of an acne picea. The water should be fresh and cool—about the temperature of the room; and in the writer's opinion and experience, hot water is injurious. Still, it is recommended by many as of value when applied for a number of minutes every night at as high a temperature as can be borne by the patient. Face steaming is also advised by some, the external remedy ordered being afterward rubbed into the skin. The writer certainly cannot vouch for the value of either one of these procedures, as he himself has never found them other than objectionable, increasing the amount of the eruption, inducing often a seborrhœa oleosa, accompanied by a relaxed condition of the skin and dilated follicular orifices, and causing the skin to have a sieve-like appearance. He has also found that these procedures were liable to cause a persistence of the process and to occasion frequent relapses. The same statements he would also make in regard to facial massage, so frequently recommended and used to-day, as in his experience he has found that it often causes an outbreak of acne and invariably aggravates a pre-existing one. Still all of these may in some cases be beneficial, but they certainly are not adapted for all, and should not be made use of as regular modes of treatment.

The comedones should be dealt with according to the directions given under that section. Curetting, both for them and the acne lesions, has been recommended by various writers—Hebra. Jr., Fox, Brocq; a dermal curette is used, and the face is gone over and thoroughly scraped once every week or ten days. The operation is rather painful, and though at times there may be rapid improvement, yet unless the patient is treated locally and internally at the same time, the relief is only temporary and a marked relapse is apt to follow. I wish to emphasize this statement because in a large number of cases which have come under my observation the previous treatment consisted solely of repeated curetting, and yet the relief afforded had been only temporary. Incision of all the lesions with a sharp-pointed bistoury and complete evacuation of their contents constitute very desirable steps. When the acne lesion has been quite large, or a veritable abscess has formed (through the coalescence of several lesions), or such an abscess has re-formed despite repeated openings with the knife, it is advisable to swab out the cavity with pure carbolic acid or with pure or fifty per cent. ichthyol. An ordinary match slightly sharpened is all that is necessary for conveying the antiseptic into the cavity. For lesions which are indurate, indolent, and obstinate, not containing pus, linear scarification has been recommended by Vidal and electrolysis by Brocq. The latter procedure invariably, however, causes more or less marked scars. For the obstinate lesions, the writer has obtained good results from the Emplastrum hydrargyri, or from pure ichthyol, or from the Unguentum hydrargyri nitratis diluted one-half or more. The local agents and remedies which have been used and recommended for the treatment of acne are innumerable and of the most various kinds. Yet all which will be found beneficial possess some degree of antiseptic action. The application chosen should vary according as the process is acute in character, or partakes rather of the indolent and chronic type. For the former, soothing applications should be used, and for the latter those which are stimulating and capable of causing a certain amount of active reaction in the tissues. In all cases, liquid agents, solutions, etc., are far preferable, and only occasionally are salves and greases advisable. When the eruption is acutely inflamed, there can be used a lotion of ℞ Magnesiæ carbonatis, Zinci oxidi, āā gr. xv.; Acidi carbolici, gr. x. (or Acidi borici, gr. xv.; or resorcini, gr. v., etc.); Aquæ rosæ, ℥ i. M. Calamine may be substituted for the magnesia in the lotion, or aqua calcis can be used instead of the rose water. Other lotions suitable for these cases are: Liquor plumbi subacetatis diluti, or ℞ Bismuthi subnitratis, ℈ ij.; Ichthyoli, gr. xv.; Aquæ rosæ, aquæ calcis, āā ℥ ss. M. If the patient's skin is a dry and harsh one and a seborrhœa oleosa does not complicate the acne, then an ointment can be used. Suitable ones would be: ℞ Acidi salicylici, gr. xv.; Zinci oxidi, gr. xl.; Unguenti aquæ rosæ, ℥ i. M., or a two per cent. ichthyol ointment, or one containing acid. boracicum, three to five per cent., etc. The remedy chosen should be kept more or less constantly on the affected surface, in order to obtain the best results, and if possible it should therefore be used both day and night.

The large majority of acne cases being, however, of the chronic type, a greater choice of remedies is needed, and they are also required when the acute stage of the disease has subsided and the case has also become indolent in character and course. Of especial value are applications containing sulphur. It may be used in powder form mixed with starch in the proportion of one to four, or as high as one to one, that is, equal parts. But it is in lotions that sulphur is most useful, though many recommend it in the form of a ten-per-cent. ointment or paste. ℞ Sulphuris sublimati, gr. l. to ʒ ij.; Cretæ præparatæ, kaolini, āā ʒ ij.; Unguenti aquæ rosæ, ℥ i. M. Apply freely at night and remove with soap and water next morning, and then rub in well a two-per-cent. salicylic or other mild ointment, or apply a three- to five-per-cent. boric-acid lotion several times through the day. A very strong resorcin paste is also of benefit at times. Its strength may be from ten to twenty-five per cent. or even more according to the indolent nature of the case. It should be applied by the physician and its effects closely watched, as resorcin has a very powerful reactionary effect on the skin, and will cause a diffuse peeling

off of the epidermis. The reaction produced may give some very undesirable results, but when the procedure is carried out with care it is usually of great benefit. The number of applications necessary will vary in each case, and the paste should be discontinued when the epidermis has a seared, yellow look, and exfoliation is imminent; a mild, soothing salve should then be substituted for it. The process may be repeated a number of times, but a milder resorcin paste should be used after the first peeling has occurred. This method, which is rather heroic, necessitating the patient's confinement to the house, is of great value, but necessarily of restricted use, and, the same results being obtainable by milder measures, it should be reserved for obstinate and rebellious cases.

There are a large number of lotions in use for acne, which, together with other ingredients, contain some proportion of sulphur. Of these, there may be mentioned: ℞ Sulphuris sublimati, ʒ ij.; Ætheris, spiritus vini, glycerini, āā ʒ ij.; Aquæ calcis, aquæ rosæ, āā ʒ iv. M. (Crocker). ℞ Sulphuris lactis, ʒ iv.; Tincturæ saponis viridis, ʒ x.; Glycerini, ʒ vi.; Spiritus vini, ℥ i. M. (Elliot). ℞ Sulphuris lactis, ℥ iss.; Glycerini, ℥ i.; Spiritis vini camphorati, ʒ x.; Aquæ rosæ, q.s. M. (Besnier). These various combinations owe their efficacy for the most part to the sulphur they contain, and may be varied according to the physician's wishes. One of the most useful will be found to be: ℞ Zinci sulphatis, potassii sulphuret., āā gr. xv.; Sulphuris lactis, gr. xx.; Aquæ rosæ, ℥ i. M. When made with fresh drugs and properly prepared, this lotion is of very great value. It should be applied at night after the face has been thoroughly washed with soap and water, and allowed to remain all night. If irritation is produced, cold cream can be used during the day. But it is wise, however, to keep up the effect of the treatment even during the day, and for this purpose a lotion of boric acid can be used, or a one- to three-per-cent. solution of resorcin in water, but preferably in alcohol and water, equal parts. A very beneficial lotion is ℞ Acidi borici, gr. xv.; Resorcini, gr. x.; Acidi acetici diluti, ʒ ij; Spiritus vini, ʒ vi. M. Potassium sulphide, ʒ i., in rose water, ℥ iv., is also recommended. The mercuric salt is often of value, but it should never be used in conjunction with sulphur preparations, owing to the probable formation of sulphuret of mercury on the surface. Authors recommend ℞ Hydrargyri bichloridi, gr. xv.; Ammonii chloridi, gr. xxx. to lxx.; Alcoholi, ℥ iv.; Aquæ, Oi. M. The formula of the "Oriental Lotion" as given by Hebra is: ℞ Hydrargyri bichloridi, ʒ i.; Aquæ destillati, ʒ iv.; Ovorum iij albumen; Succi citri recentis, ʒ iij.; Sacchari, ℥ i. M. Another formula recommended by the writer is: ℞ Hydrargyri bichloridi, gr. iij. to vi.; Acidi salicylici, gr. xxx.; Acidi acetici diluti, ʒ iss.; Spiritus vini, ℥ iiss. M. When using any of these lotions, it should be remembered that more or less desquamation and peeling of the horny layer takes place, and it is advisable to warn patients of the fact. When this occurs, it is wise to discontinue the application and to use an indifferent salve until the reaction has subsided, and then to begin anew with the lotion.

Ichthyol as an external agent is most valuable in certain cases. It may be used in watery solution—five to fifty per cent.—or it may be added to any of the foregoing formulæ, with the exception of those containing mercuric chloride. The writer has found it of especial benefit in cases in which pustulation was a marked feature; and in full strength or in a fifty-per-cent. dilution it has very commonly served the purpose of aborting a beginning lesion. In those instances of acne in which from time to time one or two papules begin to develop, the ichthyol application, as mentioned, has been a most valuable agent in cutting short the career of such fresh lesions.

In the case of patients in whom there is no complication of a seborrhœa oleosa, but who have a natural dryness of the integument, ointments are especially of use. When indicated, they should be such as possess antiseptic properties, and may contain various remedial agents. Among the many recommended, the Unguenti hydrargyri ammoniati, five to ten per cent., may be mentioned, and also one made with the red or yellow oxide of mercury—three to ten per cent. A ten-per-cent. sulphur ointment may be of value, or the hypochloride of sulphur may be used—ten to fifteen per cent., or the iodide of sulphur—three to ten per cent. At times the following formula will be found a good one: ℞ Unguenti hydrargyri oxidi rubri, ʒ ij.; Unguenti sulphuris (U. S. P.), ʒ iij.; Unguenti aquæ rosæ, q.s. ad ℥ i. M. In ordinary cases the writer would advise: ℞ Acidi borici, gr. x.; Resorcini, gr. x.; Acidi acetici diluti, ʒ iij.; Lanolini, ʒ vi.; Unguenti aquæ rosæ, ʒ ij. M. In addition to these, there may be mentioned calomel ointment, three to ten per cent., β naphthol ointment, five per cent., or one containing dermatol, or oxychlorate of bismuth, etc. In cases characterized by indolence, the Unguentum hydrargyri nitratis, diluted (1 to 8, 1 to 4, or 1 to 2), is of benefit. Chrysarobin, pure carbolic acid, tincture of iodine, have also been used in individual instances with benefit. That is, there is a host of external remedies or "cures" for acne embodied in literature, but when dealing with a case of the disease it should always be kept in mind that each case represents an individual, and whatever line of treatment is instituted it should involve the use of an antiseptic, should be adapted to the peculiarities of each individual patient's skin, and should be adjusted in accordance with the intensity of the lesions existing in each case.

George T. Elliot.

ACNE NECROTICA.—(Synonyms: Acne frontalis, seu varioliformis; acne pilaris; acne rodens; acne atrophica; folliculitis varioliformis, etc.)

Definition.—A chronic, recurrent, papulo-pustular affection, having its seat about the hair follicles, leading to necrosis of the involved tissues and terminating in a variola-like scar.

Symptomatology.—The site of predilection is the forehead, at the margin of the hair, and it is this fact which gave rise to the name acne frontalis. A wider acquaintance with the affection, however, has shown that it involves other regions. It may extend to the hairy scalp, the face, the neck, and the interscapular and intermammary regions. Cases of more or less generalized eruptions of papulo-pustules terminating in necrosis and scar formation have been described, which present many of the clinical features of this malady.

The primary lesion is generally stated to be a papule which soon becomes encrusted and covers an underlying ulceration. Sabouraud describes the elementary lesion as an umbilicated vesicle always seated about a hair. Within two or three days it attains its full dimensions, about 3 mm. in diameter. Its central portion then sinks below the level of the surrounding integument, becomes harder, encrusted, and gives to the observer the impression that it is mortised into the skin. The color of the crust, at first a yellow or brownish yellow, darkens with age. The lesion may remain in this state for several weeks; exceptionally two or more pustules may become confluent.

On removing the crust or after its spontaneous separation, a red, moist, or dry depression is left which eventually becomes white like the variola scar. Superficial lesions healing with shallow depressions, and deeper ones leading to depressed scars, are generally encountered in every case (Unna).

The presence of lesions in various stages of evolution, with pigmented and non-pigmented scars of older ones, makes up the peculiar clinical picture of the disease.

Pathology and Morbid Anatomy.—It is now generally conceded that acne necrotica is a perifolliculitis probably of locally infectious origin.

Sabouraud insists that the affection demands for its development hair follicles previously infected with his microbacillus of fatty seborrhœa. It is not possible to have acne necrotica, according to this writer, unless these infected follicles are invaded by the yellow staphylococci

which are the essential agents in producing the disease. The infection takes place at the follicular opening, and from this point invades the epidermis in a circular manner, giving rise, as the process increases, to an intense leucocytosis in the papillary and subpapillary dermal regions. The final stage is characterized by a dry necrosis of all the involved tissues.

Sabouraud was unable to differentiate the yellow staphylococcus, which he found in all lesions of acne necrotica, from ordinary Staphylococcus aureus from other sources. The distinct clinical lesion to which it is supposed here to give rise may be due to the previous damage to the follicle by the microbacillus of seborrhœa, to its admixture with this organism, to a change in the virulency of the staphylococcus, or to other causes which we are at present unable to determine.

Micro-organisms had been previously described in these lesions by Touton, Unna, and myself, and others. Touton was not inclined to attribute to them any pathogenic importance. Unna, however, considers the affection due to a mixed infection with a small bacillus and his diplococci of seborrhoic eczema.

In lesions examined by myself, staphylococci were found which are probably identical with those described by Sabouraud.

In substance it may be stated that acne varioliformis (Hebra) is an inflammation of the pilo-sebaceous system, probably microbic in origin, leading to destruction of these organs and the surrounding derma, and that Bazin was correct in naming the disease acne pilaris.

Etiology.—Acne necrotica is essentially a disease of adult life. It is rarely seen before the age of thirty, and may develop late in life. Men are more frequently affected than women.

Some of the older dermatological writers attributed it to syphilis. Although sometimes mistaken for a grouped papulo-pustular syphilide on the forehead or at the sites of acne necrotica, it does not owe its existence to that infection.

Its more frequent occurrence among those in the lower walks of life, and its location in the majority of instances on the forehead, exposed to the pressure of unclean hat bands, lend weight to the theory of local infection. A pre-existing fatty seborrhœa is, according to Sabouraud, an absolutely essential condition for the development of an acne necrotica by affording a *locus minoris resistentiæ*, and determining the clinical features of the eruption.

Diagnosis.—The absence of comedones and the sites affected, together with the depressed encrusted lesions, intermingled with white and pigmented scars, easily enables one to differentiate this variety of folliculitis from acne vulgaris. Its differential diagnosis from a papulo-pustular or a grouped pustulo-tubercular syphilide is more difficult. The history of frequent recurrences extending over months or years, which patients with acne necrotica give us, together with the absence of concomitant manifestations of syphilis, should enable one to separate the two diseases. Syphilis again shows no predilection for the hairy parts of the face which the former affection does in a striking manner.

Other varieties of pustular affections of the follicles do not give rise to the peculiar and rapid tissue necrosis with its resulting variola-like scar. It is questionable whether the generalized eruption of papulo-pustules resulting in scar formation like that of acne necrotica of the face should be included with this disease in a single group.

This disseminated eruption, to which various names have been given, as hydradenitis suppurativa, acnitis, necrotizing granuloma, etc., frequently begins as a deep-seated papule about the coil glands or in the connective tissue of the derma independently of the glandular structures. While the two diseases present many similar clinical features, it is quite probable that they depend on different infectious agents. Boeck claims for the generalized eruption a close relationship with lupus erythematosus, and believes that both affections are due to the toxic products of the tubercle bacillus absorbed from a focus in some part of the body.

Prognosis.—It is not difficult to cure a single attack of the eruption, but recurrences are the rule, and we have no certain means of preventing them or of limiting their frequency.

Treatment.—The various internal remedies recommended by dermatological writers have probably no value in curing the attacks or preventing relapses.

The lesions are quite readily healed by ointments containing sulphur, resorcin, β naphthol, salicylic acid, ammoniated mercury, or calomel. These drugs may be used in the strength of two to five per cent. or stronger.

Careful attention should be paid to the hygiene of the scalp and to personal cleanliness, as the agent producing the infection is probably widely scattered.

The scalp should be frequently washed with the ordinary tincture of green soap, followed by lotions containing bichloride of mercury, 1:1,000, to insure its disinfection. Resorcin lotions (two to ten per cent. in alcohol and water, equal parts), with the occasional use of sulphur or salicylic acid ointment, may be used alternately with the bichloride lotion. It is only by the persistent use of local antiseptic applications, not only to the eruption itself, but to the surrounding skin, that we may hope to prevent or delay relapses.

J. A. Fordyce.

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ACNE ROSACEA.—(Synonyms: Acne erythematosa; gutta rosacea; acné rosée; Couperose; Kupfernase; etc.)

Definition.—Acne rosacea represents not one disease, but a rosacea with a superimposed acne. Rosacea is a congestive disturbance affecting the nose and portions of the face, transitory at first, but afterward becoming permanent, and represented by redness, dilatation of the cutaneous blood-vessels, the formation of a telangiectasis, and in some instances by more or less hypertrophy of the connective tissue and the glandular elements of the skin. The acne lesions developing in the course of the process are secondary products, and are expressions of an inflammatory process affecting the sebaceous glands.

Symptomatology.—Rosacea attacks especially the nose and the neighboring portions of the cheeks, though it may extend laterally to the malar prominences, or even implicate the forehead and the chin, and in some cases the entire face, with the exception of the orbital spaces. The symptoms characterizing the process vary in degree and in intensity according to the stage and the grade of the affection. In the earlier stages, there is only more or less marked hyperæmia or congestion of the nose and cheeks, occurring after eating or drinking, or after exposure to cold, or at the time of menstruation. The symptoms are usually transitory, and, remaining in existence for a short space of time, disappear without leaving a trace. The patients generally complain that there is at the time a sensation of heat or of burning, but yet the skin itself is cold to the touch. This recurrent congestion may take place for a variable length of time, alternating with a return to normal conditions; but sooner or later the hyperæmia occurs more often and apparently without cause or inducement, and gradually the redness becomes a stable and permanent fact, varying only in degree from time to time. The congestive disturbance, when permanent, is diffuse and sluggish in character, without definite outlines, and the redness returns only slowly after pressure. At times, however, it may be active and may simulate an erysipelas or acute dermatitis. When exposed to the cold, the affected surfaces are liable to become bluish and cyanotic in appearance.

The stage of permanent congestion may persist for a

variable length of time without any further change occurring in the skin. But sooner or later there develops upon the nose and other surfaces a condition of telangiectasia, represented by fine, tortuous, dilated blood-vessels. These vary in size, being usually more prominent and larger on the alæ nasi, and they sometimes present in their course distinct varicosities. The telangiectatic condition may be slight or severe, and in some cases attains such a height that the entire nose and cheeks are covered with distinctly evident tortuous vascular dilatations, varying in color from bright red to purplish red, according to the temperature and the somatic condition of the affected individual.

The process, as a rule, does not progress beyond this stage, but occasionally and after long existence, a fibroid degeneration of the surface attacked takes place. It is the nose, however, which, as a rule, is the seat of this change, the other portions of the face being affected only to a slight degree and moderately thickened. The nose under these conditions becomes hypertrophied as a whole, and on portions of its superficies there may in addition arise lobulated or pedunculated, firm growths of various size, which sometimes attain enormous development (rhinophyma).

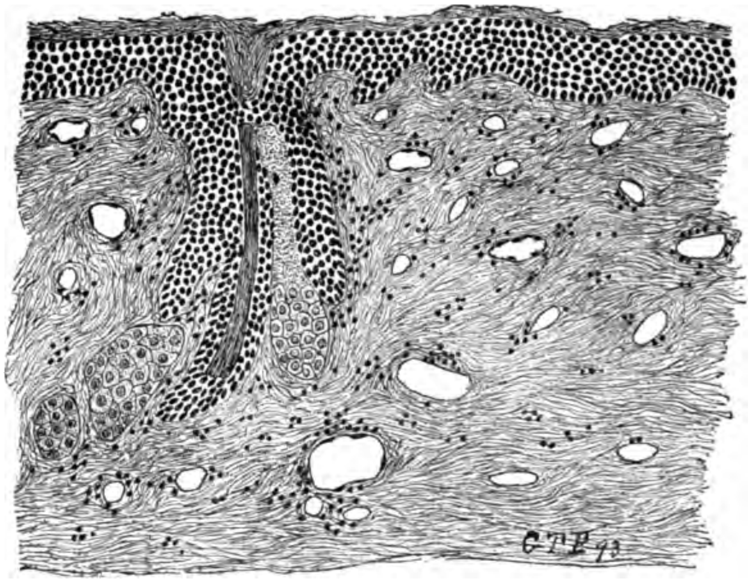

FIG. 16.—Acne Rosacea, Showing Dilated Blood-Vessels. (Author's drawing.)

In all of the stages of rosacea a seborrhœa oleosa generally coexists. The affected surface is greasy, the orifices of the sebaceous glands are dilated, and minute drops of oil can be seen exuding from them after the flushing has subsided, and even independently of the hyperæmia. When the congestion has become permanent, these orifices may be so excessively dilated that the skin has a sieve-like appearance, but it is in the hypertrophic form of rosacea that the greatest degree of dilatation is found. In other cases, the affected surface is scaly and dry or covered with small, thin, yellowish scales, or with larger greasy, soft crusts. The patients complain of itching and burning, and these symptoms are invariably associated with a yellow, scaly discoloration of the interpalpebral space and with a certain grade of what is generally called pityriasis, or seborrhœa sicca capitis. The clinical picture presented by these cases is quite distinct from that of the others described and represents a complication of rosacea and dermatitis seborrhoica. In fact, the presence of the latter process alone may and frequently does lead to the same congestive and hyperæmic objective appearances as originate from other and different internal causes.

A further and very common complication of a rosacea is acne, which, in the majority of cases, sooner or later arises on the congested surface. It is when the two processes are combined that an acne rosacea may be said to exist. The lesions may be either of the superficial (simplex) variety or of the deeper (indurata), or both may be present. They will be found on the nose and cheeks, singly or very numerous, and occurring in numbers on the nose, in which organ they frequently cause considerable deformity and also very marked pain. In themselves, the lesions differ in no wise from those others which occur independently of rosacea.

The course of the process is always a slow one, and, having developed, it persists in varying degree for an indefinite period of time, or until its inducing cause or causes have been removed by appropriate care or treatment. Slight subsidences of the congestive disturbance and of the acne lesions are generally seen to alternate with exacerbations.

PATHOLOGY AND MORBID ANATOMY.—Rosacea is primarily a vasomotor neurosis, resulting in retardation of the circulation in the superficial capillary plexus. Although at first transitory, this paretic condition of the blood-vessels becomes, through frequent repetition, somewhat fixed. In consequence the congestive redness becomes permanently established, and the telangiectases and varicosities gradually become evident. The implication of the blood-vessels is not limited to the superficial ones, but may extend to the deeper plexus, and so all the vessels throughout the skin may be affected. In consequence of the congestion, the sebaceous glands are influenced and the seborrhœa oleosa arises. The acne lesions owe their origin to the resulting debased nutrition of the skin. In some cases new connective tissue forms about the blood-vessels and the follicles, thus producing a thickening of the corium and causing ultimately either the hypertrophic form of the disease, or, in very severe cases, rhinophyma. On the other hand, one form of the hypertrophic stage is attributed to an increase in size of the sebaceous follicles.

The histological anatomy of the first stage of rosacea has been found by the writer to be represented by a dilatation of the blood-vessels in the upper portion of the cutis and by a few collections of round cells about them. In the second stage, there was an increase in degree in these features, many dilated vessels having thin walls, and large lumina being found widely distributed throughout the corium, which was also slightly thickened and œdematous. In the third stage (rhinophyma), marked hyperplasia of the connective-tissue elements of the skin had taken place, and the sebaceous glands were also somewhat enlarged. The blood-vessels were large and tortuous and their coats were thickened. Substantially the same changes have been found by others, but Unna also ascribes the formation of the growths in some cases to an enlargement and multiplication of the sebaceous glands, which thus constitute the major part of the rhinophymatous change. In other cases he states that the connective-tissue hypertrophy predominates, though the glandular change may also be a prominent feature. The investigations of Hans Hebra led to practically the same conclusions. The histopathology of the acne lesions occurring in connection with rosacea does not differ from that of the same efflorescences which arise independently.

ETIOLOGY.—Rosacea develops more frequently in women than in men, and while occurring especially after the age of thirty and in older people, yet it also is

not infrequently seen in younger persons. It arises in women very commonly in association with puberty, with menstrual and utero-ovarian irritation, and especially at the menopause. It also is liable to appear during pregnancy, in sterile women, and very frequently among those others who come in the category of old maids. In both sexes, disorders of the gastro-intestinal canal are potent factors in the production of the congestive disturbance, and in individual cases there will therefore be found such disturbances as constipation, gastric or intestinal indigestion, fermentative processes, etc. Anæmia is often the basis of the cutaneous disease, and so also is plethora. The gouty and rheumatic diatheses are prone to favor the development of the disease both directly and through those functional and other disturbances which are so liable to occur in those who are subjects of these constitutional conditions. Sedentary habits strongly predispose to the process, and hence rosacea and its accompanying feature, acne, very commonly affect seamstresses, sewing girls, and others obliged by their occupation to forego outdoor or physical exercise. In connection, however, with their confining occupations, it should also be mentioned that these same individuals are usually subjects of functional bodily disturbances, due to their diet and poor hygiene. The morphine habit has been claimed to produce the disease, and it has also been attributed to various intranasal processes, such as atrophic and hypertrophic rhinitis, chronic catarrhal inflammations of various degrees, and sycosis of the vibrissæ. Seborrhoic dermatitis is claimed by Unna to be a most important cause of rosacea in women. It would be more correct, however, to regard its effects when located on the nose as in the line of producing a redness similar to rosacea, through the inflammatory congestion incident to its presence, than to claim that it causes that latter disease itself. Exposure to cold and bad weather is an external factor in the etiology of the process. The writer has seen sunburn determine its existence, and in a number of cases a slight chillblain condition of the nose led to objective symptoms simulating accurately a mild rosacea. Face steaming, use of very hot water, continual exposure to the heat of a fire—all enter into this category. The effect of diet and abuse of spirituous liquors is generally very well known. The articles of diet which are injurious are practically the same as have been mentioned for acne, and their effects are not so much in themselves, as in the gastro-intestinal and other disturbances which they may bring about. When used in excess, all liquors may lead to the development of a rosacea, but the most pernicious are fermented drinks, such as ale, beer, porter, and also sweet wines and liquors, port, etc. Tea, when improperly used, may have a similar influence, owing to the injurious effect of the tannin on the gastro-intestinal canal. The influence of smoking in itself is certainly remote, though it possibly may indirectly operate through the production of a catarrhal or other intranasal irritation. In many cases, however, no definite etiological cause can be discovered.

Diagnosis.—The diagnosis of rosacea will be obtained from the history of its development, as well as from the clinical symptoms presented by it. As the disease occupies, as a rule, the nose and neighboring portions of the cheeks, it will be found that the persistent redness was preceded by intermittent flushing, and was followed by superficial capillary dilatation and the formation of telangiectases and varicosities. Lupus erythematosus, which commonly occupies the same surfaces, may be differentiated from a rosacea by the distinct delimitation of the patches constituting it. The outlines, though irregular, are sharply defined, the edges are usually elevated and enclose a scaly area. The patches tend to enlarge by peripheral extension, and as a rule atrophic changes occur over the affected area.

Erythematous eczema should also be differentiated from rosacea. Its occurrence is not limited, however, to the same localities, but it appears anywhere on the face, or neck, or other surface. It appears bruskly as an acute process, which in time may become chronic in character. The affected portions are somewhat swollen from serous exudation; they are scaly and rough to the touch, or have a glazed, varnished appearance, and there is much burning and itching. When syphilis exists on the nose, either in the form of the papulo-pustular-grouped syphilide or when there are cutaneous gummata, errors in diagnosis are not only possible, but are not infrequent. If attention, however, is paid to the history of the development of the redness and of the lesions discretely located or aggregated together in groups upon it; if it is noted that beneath the crusts distinct ulceration with subsequent scarring occurs, and that there is a tendency as regards the gummatous lesions to serpiginous extension with consecutive cicatrization, then the diagnostic difficulty should give no trouble.

The term erysipelas is used very loosely both by medical men and by patients, and it is a most common fact to hear the latter complain of an erysipelas, which in reality is a rosacea of several months' or years' standing. They often state that their diagnosis was that made by their physician. It should, however, be remembered that, though erysipelas does frequently affect the nose primarily, yet it is an acute process, begins with slight or marked chills, and is accompanied by elevation of temperature and such other somatic disturbances as are never associated with a rosacea.

Prognosis.—The prognosis of this cutaneous affection will depend to a great extent upon the possibility of removing its inducing cause or causes in any given case and upon the ability to prevent their recurrence. An entire and absolute cure is obtainable and can be effected, or if not this much, at any rate a most decided amelioration of the symptoms.

Treatment.—In the treatment of rosacea or acne rosacea, very much the same procedures are called for as have been detailed for acne simplex and acne indurata. The cases require both internal and external care, the former being such as will remove or modify that defect in functional or physical health which may be found in the case under consideration at the time, and the latter being such as will bring back tone and vasomotor control to the paretic blood-vessels, or will destroy them, or, in the severest grades of the disease, will remove the disfiguring growths which have arisen. In general it may be said that all internal medication should be such as will correct the existing constipation or gastro-intestinal disturbance present in the case. If uterine or ovarian irritation exists, it should be attended to; and also gout, rheumatism, and lithæmic conditions should receive proper attention. Anæmia or plethora, the tuberculous diathesis, and every other factor should be properly estimated and seen to, and all matters pertaining to errors of diet should be diligently investigated. As a rule, cheese, oatmeal, sweets, pastries, nuts, fermentable articles, and such as are highly seasoned, stimulating, and liable to tax the digestive powers, should be forbidden. Beer and alcohol and all sweet beverages should be stopped, though a light claret with water or a dry Moselle wine may be allowed at meals. Coffee without milk is perfectly allowable, but tea should be cut off, unless it is very weak and freshly made. With these exceptions, the diet should be of a simple, easily digested, and nutritious character. The needs and digestive capabilities of each patient should be studied, and the food taken should be such as is found appropriate.

So far as drugs are concerned, it may be stated that in many of the cases in which the process is in its inception, in which the redness has not become persistent, but is represented by periods of flushing and of retrogression, the mineral acids are particularly useful. Especially is this the case with the dilute nitric, muriatic, or nitro-muriatic acid. Another class, however, may require alkaline remedies and diuretics, the citrate and acetate of potash, or some of the more recent ones, uricedin, urotropein, aspirin, etc., or it may be saline purgatives that are called for. By means of these it is possible, in the early cases, to divert the blood current from the face to

some other part of the body. When the congestive disturbance of the nose and face has become a stable fact, then a very useful remedy is ichthyol. Beginning with doses of gr. v., it should be increased until gr. xv. are taken t.i.d. It may be given in pill or capsule form, or simply diluted with water or coffee. Tolerance to its peculiar taste is quickly established, and only rarely have I found the remedy to be objectionable or distressing to the patient. Besides these particular remedies—and they should be given in conjunction with those others demanded by the necessities of the individual case—ergot and ergotin have been recommended, as well as belladonna, digitalis, quinine, cod-liver oil, etc. But all of these are intended to meet indications furnished by certain cases, and should not be regarded as of general or extended value. Arsenic may be said to be always injurious in rosacea. The local treatment is of the utmost importance, and some, if not many, instances of the disease may be relieved by it alone. In acute cases, characterized by active hyperæmia and burning, soothing applications are to be used. The magnesium carbonate and zinc oxide, or the calamine and zinc lotion referred to in the article on *Acne*, is indicated; or a lotion of ℞ Bismuthi subnitratis, gr. xxx.; Bismuthi oxychloratis, gr. xl.; Magnesiæ carbonatis, gr. xx.; Aquæ rosæ, ℥ i. M. et S., or the Liquor sodæ chlorinatæ diluted 1:20, or less, or more, may be applied. A very thin boiled starch poultice is frequently of great value, as is also the official Liquor calcis

The majority of the cases of rosacea coming under treatment are, however, of the chronic type, have passed beyond the primary stage, and require a very different order of local treatment—one which is stimulating in its effects and which is intended to improve the vasomotor tone of the paretic vessels. For this purpose, stronger applications than are needed in acne in general are called for, and for this purpose a stiff paste is often useful—℞ Resorcin, gr. l. to cl.; Kaolin, Zinci oxidi, āā ʒ ij.; Unguent. aquæ rosæ, ℥ i. M. In place of the resorcin, ichthyol may be substituted in the strength of ten to fifty per cent., or the ichthyol may be used pure. The pastes are applied every night until a decided reaction has been produced and the horny layer has a glazed appearance and is beginning to exfoliate. The paste used should then be replaced by a mild, soothing ointment, ℞ Acidi salicylici, gr. x.; Zinci oxidi, ℈ ij.; Unguent. aquæ rosæ, ℥ i. M., or any other similar salve. When the exfoliation has ceased, the surface will be found much improved in all probability, and the same paste, or a weaker one, may again be applied and the same course followed. This procedure may be kept up until all the redness has disappeared, or toward the end the lotion given under *Acne*—℞ Zinci sulphatis, Potassii sulphidi, āā ʒ ss.; Sulphuris lactis, ʒ i.; Aquæ rosæ, ℥ i. M.—may be applied. To obtain the same result, caustic potash solutions (two to ten per cent.) have been recommended, or vigorous washing with green soap. Likewise Vleminckx's solution in full strength or diluted one-half, or even weaker, is at times of benefit. Chrysarobin has been advised and used, but the danger of conjunctivitis from its application on the face renders it of doubtful service. When seborrhoic dermatitis is the cause of the rosacea, resorcin and sulphur are particularly called for. They may be used either in ointment form or in water, or in alcohol and water, equal parts.

The acne lesions which may be coincident with the rosacea do not require any special treatment, but the telangiectasia and dilated blood vessels remaining after subsidence of the congestive disturbance have to be dealt with. They may be destroyed by multiple scarification, care being taken to split the vessel longitudinally with a fine-pointed knife and then to make transverse incisions. It has been recommended to touch the open vessel along its length with nitrate of silver, but that usually leaves a scar as a result. Iodine and pure carbolic acid have also been advised, but when the scarification has been properly done, none of these measures is necessary. Excellent results are obtained from electrolysis, and also from the use of the thermocautery. As regards the former, the needle used for electrolytic destruction of superfluous hair is all that is necessary. The needle attached to the negative pole of a galvanic battery should penetrate the vessel before the circuit is closed—that is, before the electric current is turned on. The positive pole—sponge moistened with water or salt solution—is grasped by the patients after the needle has been introduced into the vessel. The procedure is very painful and requires much time, and scarring is very liable to result. The thermocautery acts on the same principle, but it is neither as painful nor as liable to cause scars. A needle point should be used, such as is furnished with the Mikrobrenner introduced into practice by Unna of Hamburg. Much the same result may, however, be obtained if an ordinary sewing needle grasped by a needle holder be heated in an alcohol flame and made use of to puncture the dilated blood-vessels in their course. The method is simple, and I have found it absolutely as efficacious as the more showy and impressive ones previously mentioned.

When the case is one of hypertrophic rosacea, in which the development of connective-tissue growths in greater or lesser degree has occurred, surgical interference is called for. Ablation of the excrescences is necessary and may be done with the knife or the galvanocautery. Electrolysis has been recommended, but is of uncertain value, if not entirely without result. *George T. Elliot.*

ACOIN (Di-para-anisyl-mono-phenetyl-guanidine-chlorhydrate).—Introduced in 1899 by Trolldenier as a local anæsthetic, it has been found to have an action similar to that of cocaine but without systemic effects. Its anæsthesia is more rapid and of longer duration than that of cocaine, and is increased by the addition of a little of the latter. Trolldenier's original solution consisted of 1 part of acoin in 1,000 parts of normal salt solution. Darier recommends acoin, gr. i., cocaine, gr. ii., dissolved in 100 minims of 0.8 per cent. sodium chloride solution. Dropped into the eye, acoin has practically the same effect as cocaine, but when injected into the subconjunctival or subcutaneous tissues there is none of the intense burning sensation which cocaine may produce. In strong solution acoin is caustic.

W. A. Bastedo.

ACONITE, Aconitum.—(*Monkshood, Wolfsbane.*) "The tuber of *Aconitum Napellus* L. (fam. *Ranunculaceæ*)" (U. S. P.).

Aconitum L. is a genus of some sixty species, distributed almost throughout the Northern hemisphere. Many of the species resemble one another so closely that even from the examination of complete specimens, with flower and fruit, botanists have reached the most diverse conclusions regarding their identity or distinctness. It is therefore not remarkable that the detached medicinal portions should be found difficult of differentiation, or that various species should have been found mixed in commerce. As the chemical and medicinal properties of the different species vary greatly in degree, the tubers of at least one species being used for food, these mixtures become serious in the case of such an important drug. Of late, much more care has been exercised than formerly, so that this adulteration, intentional or accidental, has become infrequent. Partly because of this element, and partly because experiment has proven the activity of the drug to increase under cultivation, the British Pharmacopœia now requires that only the cultivated English tuber shall be supplied. It is also cultivated in various continental localities. These cultivated products are much more expensive than the ordinary drug, but their specification appears fully justified, except when a standardized drug or preparation (see Composition) is employed.

The official species occurs abundantly in the mountainous districts of Central Europe and Asia, extending up the mountain sides to a very high elevation, as well as deep into the valleys. The plant is cultivated as an

ornamental flower in the United States, where occasionally it escapes. The tubers used in medicine are chiefly collected in Europe.

Since the herb, although unofficial, is much used in medicine, the entire plant is here described. The simple, stiff, upright stem of aconite rises from 50 to 100 cm. (20 to 40 inches) from the ground, bearing numerous alternate leaves, and a long, close, terminal, spike-like, raceme.

FIG. 17.—*Aconitum Napellus* L.

The leaves (*Folia Aconiti*, B. P.) are sub-rotund, from 5 to 20 cm. in diameter (2 to 8 inches), rather stiff and thick, smooth, shining, and dark green above and paler below. The blade is palmately three-parted; the lateral segments are again divided nearly to the base. The narrowly wedge-shaped divisions are further three or two lobed, and these lobes are again incised, or cleft, with linear and pointed tips. The leaves become less compound toward the upper part of the stem, and are finally reduced to three or several cleft bracts. They have no marked odor, but upon being chewed produce, like the tuber, a persistent stinging sensation in the mouth. They are poisonous and contain a small and uncertain amount of *aconitine* and considerable *aconitic acid*, the latter of no therapeutic importance. The flowers are of striking appearance; the corolla is nearly wanting, and its place is taken by a large colored calyx, of which the upper sepal is developed into a deep cup-shaped helmet, that sits upon the rest of the flower like a bonnet (Fig. 18). The pistils are three, containing numerous small ovules.

The mature tuber gives the specific name to the plant (*napellus*, a little turnip). It is a simple, conical, tapering tuber, ending in a long, slender, cylindrical tap-root, and bearing numerous rootlets upon its sides (see Fig. 19). From its scaly crown arises the flowering stem, and at the base of this stem a short stolon extends horizontally under the ground, and bears on its extremity a young tuber, more or less developed according to the season, and destined to produce the plant of the succeeding year. There may also remain upon the other side of the crown a similar but dead connection between the present tuber and the remains of that of the preceding year. This habit of growth well enables us to determine the season when the tuber was collected. When it shall become positively determined at what season it is most active, this knowledge will doubtless prove of the greatest value to us.

Fresh *aconite tuber* is brown externally, white within, and has a biting, benumbing "taste," which has caused it to be occasionally stupidly mistaken for horseradish.

FIG. 18.—Entire Flower of *Aconitum Napellus*.

The *dried tuber*, which constitutes the usual drug (*Aconitum*, U. S. P.; *Aconiti Radix*, B. P.; *Tubera Aconiti*, P. G.; *Racine D'aconit napel*, Codex Med., etc.), is from 1 to 2 cm. in diameter at the base, and from 5 to 7 cm. in length (two-fifths to four-fifths inch, by 2 to 3 inches); much shrivelled and wrinkled longitudinally, especially below; often curved and twisted, or broken. The external color is dark brown; internally it is grayish, showing, in a transverse section, a distinct, five to eight pointed stellate cambium ring, in each angle of which is a well-developed fibro vascular bundle. Frequently the tubers are attached in pairs; when not, the scar where they were broken apart can be seen. The taste is similar to that of the fresh root, but the stinging sensation may be a little delayed.

Aconite, even when coming solely from *Aconitum Napellus*, is very variable in quality and often poor. The age of the root has much to do with this. Grown in different countries, or under varying circumstances, it is subject to considerable variation in quality.

COMPOSITION.—Its active constituent is the alkaloid *Aconitine*, described below. The determination of its percentage, which is very irregular, therefore constitutes a perfect method of estimating its quality. Owing to difficulties in its extraction, this determination has in the past not been found practicable, but it is altogether probable that such a method of assay will be incorporated into the forthcoming edition of the Pharmacopœia. It has also been proposed to determine the presence of the normal percentage of alkaloid by securing the tingling effect upon the tongue and lips by the use of a solution of a specific degree of dilution; but the personal equation is so great, and the effects of training so important, that this method has not found favor. The total alkaloidal contents should be about seven one-hundredths of one per cent. Besides the alkaloid, a large amount of aconitic acid, combined with calcium, is present. Resin and slight amounts of fat and sugar are also found.

FIG. 19.—Tubers and Roots of *Aconitum Napellus* L.

The aconites were known to the ancients, both in Europe and Asia, as poisons, and are said to be still used by some of the hill tribes of India to envenom their arrows. They were employed as medicines in Germany in the twelfth, and on the islands of Great Britain in the thirteenth centuries, but afterward fell into disuse until 1762, when Stoerck, of Vienna, again introduced them to the medical profession, since which time they have been constantly used.

PHYSIOLOGICAL ACTION.—There is nothing in the composition of aconite which materially modifies the action of the aconitine.

Primary Effects.—It sharply stimulates certain of the nerve endings on coming into contact with them, as well as certain of the encephalic centres. These effects upon the nerve endings are evidenced by a tingling sensation in the skin, whether the aconite be directly applied or be carried there in the circulation. A similar tingling is produced upon contact with the mucous membrane, and this becomes a severe irritation when the drug is applied in concentrated form, as when the dust of the alkaloid is inhaled or reaches the eyes. This effect of aconite upon the mouth is markedly to increase the salivary and mucous secretion. It produces some increase of perspiration in the same directly stimulating manner on being carried to the skin. Under careful observation, spasmodic contractions of voluntary muscular fibre can be seen, while stimulation of the vasomotor mechanism (whether central or peripheral is not certainly known)

results in arterial constriction, when other and antagonistic influences resulting from the drug's action are excluded. At the same time, the pupil is temporarily contracted. Under the same conditions of control, increased cardiac action is observed. A slight diuretic effect, in spite of decreased blood pressure, is probably due to direct renal stimulation. Stimulation of the medullary centres is plainly evidenced by the strong cardiac inhibitory action which is the most prominent effect of the drug, and in convulsions, which in poisoning often occur before the respiration has failed sufficiently to produce them. There is a powerful stimulation of the respiratory centre, though the action is temporary, irregular, and spasmodic. The vomiting which is often present may also be due in part to the same central stimulating cause. When nausea is present, the diaphoresis is increased. The powerful slowing of the vagus results in a marked slowing of the heart, and as the systole is much the more abbreviated, the heart is weak as well as slow, and blood pressure is reduced. The temperature falls, partly owing to this cause, partly to the perspiration, and, some think, partly by reason of the disturbance of the heat centres.

Secondary Effects.—The secondary effect of aconite is to paralyze the parts at first stimulated, though these are affected in very different degrees as to both strength and promptness. Failure of the sensory nerve endings produces anæsthesia where tingling before existed, so that a sensation of numbness is experienced. The stimulated respiration changes to a depressed one, and convulsions from this cause frequently ensue in poisoning. Vasomotor constriction disappears, as does secretion due to peripheral stimulation. The pupil often becomes dilated.

The promptness with which these secondary symptoms appear is proportional to the size and concentration of the dose, so that the primary symptoms may be almost altogether wanting. In all cases, they supervene so soon, and are so much more pronounced and continuous, that they, rather than the primary, constitute the medicinal effects of the drug. Of all, the cardiac repression and lowered arterial pressure, which are continuous, are the most prominent effects.

In poisoning, conspicuous modifications of the medicinal effects occur. The heart becomes very erratic, although upon the whole weakness is rapidly progressive. The respiration is painfully depressed and convulsive. Muscular weakness, which may be quite persistent even after recovery, is added to nerve depression. Respiratory failure is the usual cause of death. This, with cardiac paralysis, is sometimes almost instantaneous when large quantities of a liquid preparation are swallowed.

Otherwise, the above-described symptoms come on successively. The tingling and numbness of the mouth are very characteristic, and are succeeded by similar sensations over the surface of the body, especially in the hands and feet. The skin soon becomes cold, though there is more or less perspiration. There is dilatation of the pupils. There is progressive muscular weakness, accompanied by feebleness and ultimately, in fatal cases, paralyses of respiration.

Although some aconitine is excreted, especially by the urine, it is for the most part quickly burned up in the system, so that if a fatal result is not prompt, recovery is apt to occur. Atropine is a physiological antidote, as is digitalis. External heat is very important. Alcohol should be used cautiously.

Aconite is one of the most useful drugs of the Pharmacopœia. It works especially well with children, and even very small doses often work satisfactorily. Because of the rapidity with which it is destroyed in the system, doses should be small and often repeated. The special cases in which it is useful are those of sthenic character, in the relief of congestions. It is a very safe and moderate agent for lowering the temperature, as well as for relieving tension. It tends to lessen inflammation and is especially useful in many forms of sore throat. All forms of throbbing pain, such as earache, toothache, and headache, are likely to be relieved, as are painful disorders of the respiratory organs, such as pleurisy. Great relief is often experienced from its use in inflammatory rheumatism. Scarlet fever and the fever of measles and similar diseases are often markedly benefited by aconite, but care should be taken to avoid excessive depression. Neuralgic pains are often benefited by local applications, preferably by inunction. It must never be overlooked, however, that fatal absorption may thus take place.

The official preparations and their doses are as follows: Extract, 0.01 to 0.6 gm. (one-half to one grain); fluid extract, 1 to 2 minims; tincture (of 35-per-cent. strength), 1 to 5 minims. The strength of an ointment of aconitine should not be greater than 2 per cent., and it is best made still weaker. (See also *Aconitine.*)

Other species of aconitum having similar properties in marked degree are *A. ferox* Wall. of India, containing pseudaconitine, and *A. Japonicum* Thunb. of Japan, containing apparently aconitine, but which has been called japaconitine. *H. H. Rusby.*

ACONITE, TOXICOLOGY OF.—A preparation of some of the species of the genus Aconitum (natural order, *Ranunculaceæ*) was first suggested as a medicine by Stoerck in 1762, although its poisonous qualities were known long before that date.

The species at present in use, *Aconitum Napellus*, is popularly known as Monkshood, all parts of which contain aconitine, but the root most abundantly. The extract or tincture of the root contains besides aconitine several other alkaloids. These are:

ACONINE ($C_{26}H_{41}NO_{11}$[?]), which does not produce tingling of the tongue, and does not appear to be poisonous in small doses.

BENZOYL-ACONINE ($C_{26}H_{40}(C_6H_5CO)NO_{11}$) is the napelline of Dunstan—a substance readily hydrolyzed by alkalies or superheated steam, yielding aconine and benzoic acid. Although poisonous, its toxic power, when administered to animals, is about one-thirtieth that of aconitine.

PSEUDACONITINE—nepalin-veratroyl aconine, $C_{36}H_{49}NO_{11}$—occurs sparingly if at all in *A. Napellus*, but replaces aconitine in *A. ferox*. It is highly poisonous.

At least five additional highly poisonous alkaloids have been prepared from various species of aconitum other than *A. Napellus*.

The commercial aconitines vary greatly in composition and in therapeutic and toxic activity, containing varying quantities of aconitine from a mere trace to nearly the pure article.

The name aconitine properly applies only to the crystalline alkaloid, ACETYL-BENZOYL-ACONINE, $C_{26}H_{39}(CH_3CO)(C_6H_5CO)NO_{11}$, a faintly yellow solid, crystallizing in transparent prisms, which fuse at 188.5° C. (367.3° F.), readily soluble in chloroform and benzene, sparingly soluble in alcohol and ether, and almost insoluble in water and petroleum ether. It forms crystalline salts. The alcoholic solution of the alkaloid is dextrogyrous; aqueous solutions of its salts are lævogyrous. It is readily hydrolyzed, yielding aconine, benzoic and acetic acids. The toxic power of a solution of aconitine chloride administered subcutaneously to guinea-pigs is very high, 0.000064 gm. (0.001 gr.) per kilogram of body weight being the lethal dose.

Statistics.—Most of the aconitic poisonings reported in medical literature are *accidental*. Out of 193 cases, 157 were accidental, 26 suicides, several unknown, and 6 homicides. In 18 cases the root itself or a decoction of it was taken by mistake for some other root, usually for horseradish (*Cochlearia armoracia*; natural order, *Cruciferæ*). The points of difference in the two roots will be evident from the cut, Fig. 20 (Bentley). Poisonings have occurred from the external application of liniments and ointments containing aconite.

Lethal Dose.—On account of the variations in strength in the different preparations of aconite, it is impossible to fix with any accuracy the lethal dose. Probably less than 0.064 gm. of crystallized aconitine would be fatal.

Symptoms.—Usually the first effects of aconite or aconitine, when taken by the mouth, are manifested immediately or within a few minutes, and consist of a peculiar

tingling or prickling sensation of the lips, tongue, and mouth, accompanied by a feeling of numbness, both sensations extending until the entire surface, particularly that of the extremities, is affected. There is a horrible strangling or clutching sensation in the throat, deglutition is difficult, and, later, attempts to swallow provoke spasms which may be hydrophobic in character. The teeth feel as if loose, the throat feels dry, there are sensations of swelling of the face and forehead, and twitching of the facial muscles. Nausea is felt early, is accompanied by salivation, and quickly followed by the most violent and persistent retching and vomiting. The act of vomiting is a convulsive spasm of the abdominal muscles and diaphragm by which the stomach contents are as it were "jerked out." After a very brief period of cardiac stimulation the pulse becomes slower, more feeble, irregular, and dichrotic, then flickering, and finally imperceptible; respiration is shallow and hurried; there are chills and subnormal temperature. There is great weakness and prostration; slight exertion provokes syncope and sometimes cardiac pain. The patient is in fear of death, restless; the face is pale, the lips are blue, and the surface is covered with cold perspiration. The extremities are cold, sometimes paralyzed, and sometimes affected with pains in the joints. The eyes are staring, glistening, and the pupils usually dilated, with more or less complete loss of sight or diplopia. In some instances the patient becomes delirious, though generally perfectly conscious to the last; sometimes he is attacked with cramps and convulsions, and sometimes he is comatose. The urine is generally retained.

Many unusual symptoms are reported in the cases referred to in medical literature.

Duration.—The usual duration of a fatal case of aconitic poisoning is from one to five hours, whether the substance be taken in the form of aconite, aconitine, or the root itself. In two cases of fatal poisoning by the leaves the duration was twenty and twenty-four hours.

Treatment.—The stomach is to be washed out as soon as possible, preferably with water containing a solution of iodine in potassium iodide, which forms a crystalline, insoluble compound with aconitine. In the absence of the necessary instruments an emetic of zinc sulphate or of apomorphine may be given, notwithstanding the tendency to emesis caused by aconite. Respiration is to be maintained artificially if necessary. Diffusible stimulants, ether, ammonia, brandy, etc., should be given by hypodermic or intravenous injection or by enemata. Digitalis, strychnine, and atropine have been given hypodermically to counteract the cardiac effects of aconitine, and amyl nitrite by inhalation to control the spasms. The diminution of temperature is opposed by warmth externally applied.

Post Mortem.—The post-mortem appearances are in no way characteristic. When death is due to failure of respiration the post-mortem appearances resemble those after death by asphyxia.

Detection.—In the exceptional cases in which portions of the plant have been taken, these may be recognized in the stomach contents.

Under favorable conditions the alkaloid will crystallize from its solutions in benzene; it gives no color reaction, nor is there any special chemical test by which it may be identified.

The most sensitive reagents for aconitine are the human tongue and the frog. Minute quantities placed upon the tongue produce a peculiar tingling or prickling sensation, or if injected hypodermically they cause the death of a frog. (Compiled from Prof. R. A. Witthaus' Toxicology.)

Louis Warner Riggs.

ACONITIC ACID, $C_6H_6O_6$, occurs in large amount in combination with calcium in aconite, also in adonis and other plants of the *Ranunculaceæ* and elsewhere. Either water or alcohol will dissolve it. It deposits in thin plates. This acid is also yielded upon heating citric acid. It has no special medicinal properties.

H. H. R.

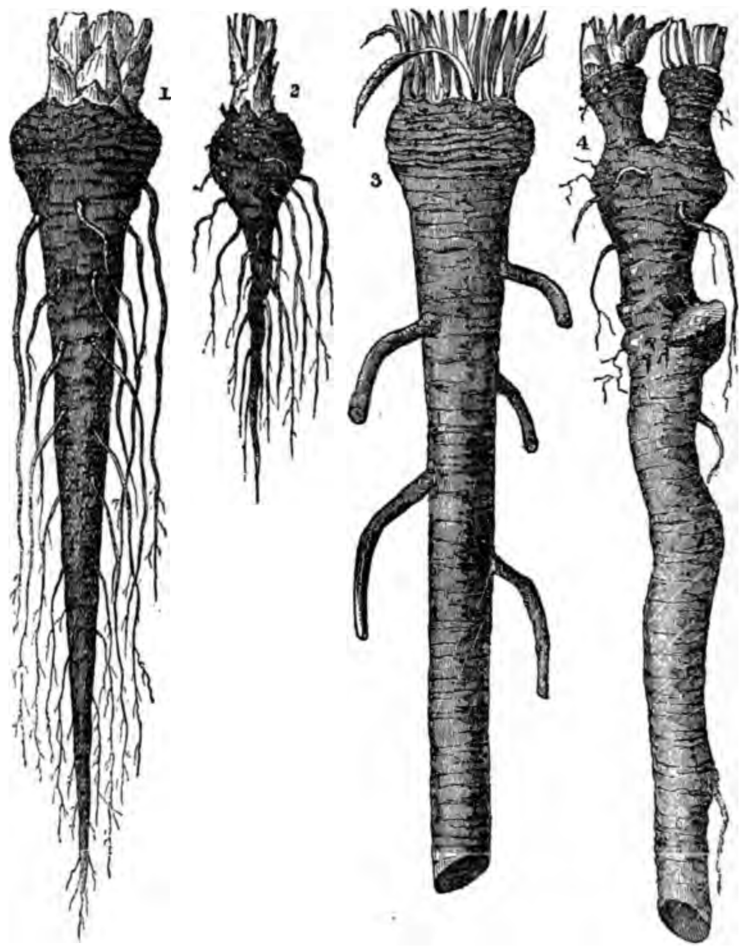

FIG. 20.—Roots of Monkshood and Horseradish. 1 and 2, *Aconitum Napellus*; 3 and 4, horseradish (*Cochlearia armoracia*).

ACONITINE.—"An alkaloid obtained from aconite root, and having the formula $C_{33}H_{45}NO_{12}$" (B. P.). (Not official in U. S. P.) As the British Pharmacopœia defines aconite root as proceeding from *A. Napellus* L., the above definition is equivalent to a requirement that the alkaloid be obtained from that species. It is, however, not confined to that species, as what is believed to be the same is obtained from Japanese aconite. Its percentage in aconite must be very small, as the total alkaloids represent but about .07 of one per cent. The percentage is, moreover, very variable, and should be stated in connection with every lot and preparation of the drug. Aconitine occurs in white, flat crystals and is soluble in

alcohol, but not in water. It is a compound of acetic acid with the alkaloid benzoyl-aconine, the latter being a compound of benzoic acid with the alkaloid aconine. Both of the two last-named occur to a greater or less extent in aconite, as derivatives of the first. Neither possesses the properties of aconitine, nor are they poisonous. To the incompatibilities of alkaloids in general, aconitine adds that of being decomposed by alkalies, owing to its peculiar composition, as above described.

The properties and uses of the alkaloid are fully stated under the title *Aconite*. Its activity is, however, so intense that it has to be used and handled with the most extreme caution, as will be appreciated when it is considered that there is but a half pound of it in a ton of aconite, yet the safe dose of aconite is limited to about five grains.

Its external use is for the relief of rheumatic and neuralgic pain. The ordinary commercial alkaloid has been used in ointment up to two-per-cent. strength, but that of the pure crystalline alkaloid should be limited to .2 of one per cent. There is great danger of absorption, and it should be applied only to the unbroken skin. Internally, it may be used in pill form or in freshly made solution, in doses of gm. 0.0001 to 0.0003 ($\frac{1}{600}$ to $\frac{1}{200}$ grain), and not more than ten times these amounts per day.

Japaconitine, from Japanese aconite (*A. Japonica* Thunb.), is apparently identical.

Pseudaconitine, from Nepaul or Indian aconite (*A. ferox* Wall.), is equally poisonous. Its properties are under investigation, and it is not unlikely that it may be found worthy of introduction. *H. H. Rusby.*

ACORMUS. See *Teratology*.

ACROCHORDON. See *Fibroma of the Skin*.

ACRODYNIA, or EPIDEMIC ERYTHEMA.—A somewhat obscure disease, said to bear considerable analogy to pellagra. It was first observed at Paris in 1828, occurring there as an outbreak in one of the infirmaries for old men. The epidemic subsided during the winter months to break out again in the spring, but was considered to have been extinguished during the severe winter of 1829–30. A few cases, however, were noted from time to time during the years 1830 and 1831, since when the affection has not again been observed in Paris. In Mexico, in 1866, during March and April, an epidemic said to be acrodynia broke out among the Mexican and Algerian soldiers at Zitocuaro.

On the Continent it had been observed on a small scale since 1831, chiefly among Belgian and French soldiers and prisoners, the last occasion being in a French regiment stationed at Satory, near Versailles, in 1874. This epidemic was not very clearly demonstrated, however, to have been one of acrodynia, and of late the existence of such a disease has even been questioned. The general symptoms are said to be in some respects similar to those of chronic arsenical poisoning. Commencing with gastro-intestinal irritation, redness of the conjunctiva, œdema of the face or limbs, there are soon added formication, pains in the fingers and toes, a burning sensation, and pricking or shooting pains in the palms and soles, and a feeling of weight in the extremities, especially the lower. Hyperæsthesia of these parts, especially the soles of the feet, and sometimes anæsthesia, are present. Cramps, spasms, and tetanic contractures are almost always constant symptoms. There is no fever, and the disease is rarely fatal, except in the old and feeble or from the diarrhœa which is present in all cases, recovery taking place in a few weeks or months.

The chief cutaneous manifestations of the disease are erythematous and pigmentary.

The erythema makes its appearance early in the course of the disease and may be very general, affecting, however, chiefly the extremities, more particularly the hands and feet, and here especially their palmar and plantar surfaces. It may be preceded or accompanied by the formation, chiefly on the hands and feet, of vesicles or bullæ filled with a clear or at times more or less sanguinolent effusion, and is followed by desquamation or exfoliation of the epidermis, while a dark brown or blackish pigmentation spreads itself over the abdomen, chest, axillæ, and other parts, being more pronounced in the warm region of the body. Alibert, in his description, the only one coming from a dermatologist, says ("Monographie des dermatoses," Paris, 1833, p. 12) that what particularly attracted his attention in most of those afflicted with the disease was this black color which affected the integument, nearly all who presented themselves for treatment having the tint of a chimney sweep.

The pathology of the disease is obscure; there are no special post-mortem changes, but in several cases inflammation of the pia mater and spinal arachnoid was found. Though the disease bears a close resemblance to pellagra, the general and cutaneous symptoms are more varied in acrodynia than in pellagra; and while in the latter the backs of the hands and feet are attacked, it is the palms and soles that are affected in the former. The disease was regarded (Chomel, Récamier, etc.) in Paris as being due to spoiled cereals, but nothing positive on the score has been proven. The most efficient treatment was claimed to consist in counter-irritation of the spine.
Charles Townshend Dade.

ACROMEGALY, or AKROMEGALY (ἄκρον, extremity; μέγας, great).—(Synonyms: Acromégalie; Akromegalie; acromegalia; pachyacrie; Marie's disease.)

DEFINITION.—Acromegaly is a chronic disease, characterized by an abnormal increase in the size of the extremities of the body, viz., hands, feet, and generally head, due to a hypertrophy of the bones and soft parts of these regions.

HISTORY.—The first to recognize this disease as a separate entity was P. Marie, who wrote upon this subject in 1886. This first article of Marie's describes two cases which he had discovered while first assistant to Professor Charcot. He named this disease "Acromégalie" because he found all the extremities of the body enlarged, viz., hands, feet, and cephalic extremity, while von Recklinghausen suggests the name of "Pachyacrie." Since the publication of Marie's first paper, in 1886, a number of cases, reported in literature under various titles, have been discovered, which in all probability were cases of acromegaly.

On the other hand, since 1886, a number of cases have been reported as acromegaly which I do not believe to be cases of that disease. The first cases discovered and reported as acromegaly (in 1885 Wadsworth reported a case as myxœdema which was undoubtedly acromegaly) in America were those of Drs. O'Connor and Adler, both of which were published in 1888.

A complete study of this disease can be made by reference to the New Sydenham Society Reports, London, 1891; to Dr. Joseph Collins' articles in the *Journal of Nervous and Mental Diseases*, December, 1892, and January, 1893; to the alphabetical bibliography in the writer's article in the *Yale Medical Journal*, December, 1897; to Dr. Guy Hinsdale's monograph in *Medicine*, 1898; and to the chronological bibliography of Dr. Harlow Brooks in the *Archives of Neurology and Psycho-Pathology*, vol. i., No. 4, 1898.

SYMPTOMATOLOGY.—*General Condition.*—The acromegalic patient comes to the physician complaining of headache, disturbances of vision, severe joint pains, and sometimes ringing in the ears; or the condition is discovered while the patient is under treatment for an entirely different disease. This pain in the head is the most frequent subjective symptom, and is often severe and even terrific. There may be, and frequently are, pains referred to various parts of the body, often to the joints, which are more or less persistent but neuralgic in character. Frequently there is tingling of the hands, feet, or ears, often with numbness of the fingers, but with no great loss of sensibility. There is generally increased and often ravenous appetite, increased thirst, and often dyspepsia and polyuria, and generally constipation. Menstruation is gen-

erally absent in the female, and the sexual appetite is generally diminished in the male. The pulse and temperature are almost invariably normal.

Previous History.—In women the cessation of the menstruation is generally the first symptom of the disease. In several cases there has been a history, in the early stages, of profuse and recurring epistaxis.

From the patient or his family proof of the continuous growth of the head, hands, feet, and body can generally be elicited, and commonly an approximate date for the beginning of the disease can be estimated. The weight during this developing period of the disease always increases, and so does the height to a certain extent, at least till the period when kyphosis develops. When this kyphosis is well developed more or less loss of height takes place, even to as much as six inches in Paget's case.

The gradual increase in the size of the hats, shirts, gloves, and shoes worn can always be ascertained, and furnishes positive evidence of growth.

In women the increase in the size of the fingers, as shown by the inability to longer wear the wedding ring, which in many cases has been sawed off, is a positive evidence of growth frequently mentioned in the histories of the cases. In most cases earlier photographs of the patient can be obtained and compared with the present condition.

These signs and facts show a positive and continuous growth, and careful examination of the parts affected shows that this growth is largely of the bones.

Clinical Inspection.—In acromegaly all of the projecting portions of the body are greatly enlarged—hands, feet, chin, lips, nose, tongue, ears, and often the genitalia. Of these parts the bones, cartilages, and soft tissues are all hypertrophied. The face is oval, the cheeks are flattened, the forehead is retreating and low, the nose enlarged and often massive, and exophthalmos may be present. The ears are generally enlarged and the hair of the head is strong and thick.

The intellectual faculties may or may not be impaired, and somnolency is sometimes present. Taste and smell are rarely affected, while hearing is occasionally disturbed and sight is frequently impaired. The voice is loud and deep. The reflexes are generally normal, at least not markedly impaired, and the electrical reactions are normal.

The skin may be dry and harsh and is generally greatly thickened, especially on the affected parts, while the subcutaneous cellular tissue may be either hypertrophied or atrophied. The skin is often yellowish, especially marked on the face, and there is often increased perspiration, either local or general. There is frequently an increased growth of hair, especially on the arms and legs, and molluscous growths often appear on the face, neck, or body.

The superficial veins of the body are often dilated, giving rise to hemorrhoids and varicose veins of the legs.

There may be muscular hypertrophy, local or general, but later there is atrophy of many of the muscles. The heart, lungs, spleen, and liver may be normal, although the heart may be slightly hypertrophied. The kidneys are generally normal, although there is frequently polyuria, and occasionally glycosuria or albuminuria is present.

The cartilages of the nose are enlarged and thickened, as are generally the cartilages of the ears and eyelids. The lower jaw is almost invariably enlarged, and generally to such an extent that prognathism is present. The superior maxillary and malar bones are generally enlarged, elongating the face and giving prominence to the cheek bones. The supra-orbital ridges are generally very prominent, causing the rest of the forehead to apparently retreat, while the skin of the forehead is enormously hypertrophied and thrown into folds and corrugations. The cranial bones, except as to crests and protuberances, are rarely affected.

The bones of the thorax are always enlarged, notably the extremities of the clavicle and the costal cartilages, especially at the junction of the ribs and the sternum, and still more markedly at the xiphoid appendix. The ribs are generally widened, while the scapulæ may or may not be enlarged, and sooner or later the vertebræ and the vertebral cartilages become affected, the latter thickening and ossifying, causing kyphosis and other deformities of the spinal column. On account of this kyphosis and the shortening of the neck the long, projecting chin often almost rests upon the sternum.

The bones of the arm are generally not enlarged except the lower part of the radius and ulna, thus causing an enlarged wrist, while the bones of the hand, the metacarpal bones and phalanges especially, are all widened and thickened.

The soft parts of the hand are especially hypertrophied, giving the large and often enormous acromegalic hand.

The pelvic bones are generally enlarged, this being particularly noticeable at the symphysis pubis and the crests of the ilia. The thigh bones are generally not affected except at the condyles, which are enlarged and, together with the almost constantly enlarged patellæ, produce large knee joints. The tibiæ and fibulæ may or may not be enlarged, though frequently there is some hypertrophy of the extremities of these bones. The ankle joints are generally enlarged, and the feet bones and soft parts are affected similarly to the hands and, like the latter, are enormous.

Critical Examination.—*Head.*—We find the forehead low and retreating, due to the growth forward of the superciliary ridges, which, with the elongation and forward projection of the lower jaw, gives the oval or elliptical face so characteristic of this disease. The hair is thick and strong, and the eyebrows are often heavy. We next notice that the face is entirely too large; that it is out of all proportion to the cranium proper. The skin of the face is thickened and of a yellowish-brown color, most marked on the eyelids, with perhaps here and there a molluscous growth.

The skin of the forehead is often redundant and thrown into many transverse wrinkles and folds. The cheeks are generally flattened, and often appear sunken, largely due to the prominence and projection of the malar bones. The circumferences of the orbits are prominent, and the eyelids are large, due to the thickening and widening of the tarsal cartilages, with more or less hypertrophy of the skin, especially of the lower lid, where it may fall in folds, with occasionally the appearance of œdema. The eyeballs are large and generally more or less prominent, even to the condition of exophthalmos.

The nose, even for the size of the face, is too large, often immense, due to the thickening and enlarging of the nasal cartilages and to the great hypertrophy of the soft parts. It is wide, thick, and may be pugged.

The superior maxillary bones may or may not be enlarged, but are frequently lengthened from above downward; nevertheless they are never enlarged to the same extent as is the lower jaw.

The upper lip is generally thick and projecting, but never attains the size of the lower lip. The lower lip is almost invariably thick, everted, and projecting, and is a characteristic feature.

The enlargement of the lower jaw is one of the landmarks of this disease, although acromegaly can unquestionably occur without the enlargement of this bone. The angle of junction between the rami and the body becomes obtuse, and, while the rami may grow to a considerable extent, the chief growth is in the body. The body of this bone widens and thickens all over, but especially on its alveolar border and at the symphysis, where the mental process becomes very prominent. The rami, however, may be so enlarged and widened as to force outward the lower part of the external ear. The teeth rarely partake of this growth (in the congenital case described by Cênas the teeth were all enlarged); hence the growth of the alveolar process soon tends to separate the teeth from one another by continually increasing intervals, though the teeth may fall out spontaneously. Sooner or later prognathism generally occurs; it is due not only to the growth of the body of the lower jaw, but also to the widening of the angle and the changes in the

glenoid fossa. This prognathism is of all degrees, even to 15 mm.

The external ear is generally increased in size, sometimes even appearing very large. The cartilages and the soft parts both take part in the growth, and the former may become in places as hard as bone, while the external

FIG. 21.—Typical Face in Acromegaly. (Author's first case.)

auditory canal may be lengthened by the growth of its cartilage and the bony canal narrowed by exostoses from its walls.

The bones of the cranium are generally not enlarged, although there have been several exceptions, but the ridges and eminences are often abnormally prominent, especially the occipital protuberance; and in one case there were spiky, osseous protuberances along the sutures of the skull.

The mucous membrane of the nostrils is frequently found hypertrophied. The sense of smell is very rarely affected.

The tongue is broad and thick and frequently double its normal size, almost entirely filling the cavity of the mouth, so that the sides show indentations from the teeth. The upper surface of the tongue is often deeply corrugated and marked by deep lines and fissures, and the papillæ may be prominent and projecting. The speech is rendered thick, heavy, and slow by the massive tongue, which gives the impression of weight and clumsiness, while the prognathism allows the labial and dental sounds to be but poorly articulated. The tongue is generally clean, but may be covered with a grayish-yellow coating.

The soft palate is often thickened, the uvula may be wide and long, even as large as a little finger, and the epiglottis has been found considerably thickened. The larynx is enlarged, either as a whole or in one or more sets of its cartilages. The aryepiglottic ligaments have been found thickened and the vocal cords hypertrophied. These laryngeal enlargements cause the voice to be loud and harsh, while the pitch is much lowered in men and made masculine in women.

The thyroid cartilage is often enlarged, as is also the cricoid cartilage and frequently the hyoid bone. The submaxillary and the lymphatic glands of the neck may be enlarged. The thyroid gland may be normal in size, hypertrophied, cystic, or so atrophied that it cannot be found.

The neck is short and thick, and the head leans forward, which with the cervico-dorsal kyphosis causes the long projecting chin to almost rest on the sternum.

Body.—Sooner or later, but almost invariably if the case is far enough advanced, the irregular growth of bone in the spinal column causes deformities of the spine. This deformity is almost constantly a cervico-dorsal kyphosis, giving a humpback appearance which is very characteristic of this disease. Occasionally scoliosis is also present, and sometimes there is a compensatory lumbar or dorso-lumbar lordosis. The spinous processes of the vertebræ are frequently found abnormally prominent, especially the lower cervical.

The size of the chest is greatly increased, especially at the level of the ensiform cartilage, where it reaches its greatest circumference. Laterally the chest appears flattened, while the antero-posterior diameter is often enormous, due to the forward projection of the lower end of the sternum.

The sternum is generally widened and thickened, with prominent transverse ridges, and there may be triangular-shaped indentations at the sides. There may be a hollowing of the sternum in the region of the manubrium due to an irregular growth of the segments, while the upper end of the sternum may be so thick as to give a dulness on percussion. The xiphoid cartilage is generally hard, wide, and projecting.

The clavicles are most enlarged at the sternal extremities, but the acromial ends are also generally thickened.

The ribs are wide and very oblique, and at their junction with the more or less enlarged and ossified costal

FIG. 22.—Author's Third Case of Acromegaly.

cartilages are generally found bony nodules, not unlike the rachitic rosary, and nodosities may appear on the ribs themselves. The ribs are rendered oblique, and the lower ones are forced outward by the great growth of the costal cartilages. The hardening of the ligaments and car-

tilages of the chest causes a peculiar stiff and constrained up-and-down or out-and-in motion of the lower part of the thorax during respiration, and the abdominal respiration is increased.

The abdomen is generally flattened and even appears retracted from the forward projection of the sternum and costal cartilages, though rarely it may be large and pendant.

The pelvis is generally enlarged, the ilia are wide apart, the crests broad and prominent, and the pubic bones are especially hypertrophied at the symphysis.

The external genitals may or may not be enlarged. The clitoris may be hypertrophied, and the vagina may be lengthened, but the uterus is generally small and atrophied.

Upper Extremity.—The shoulder joint may be, but rarely is, much enlarged; the elbow joint may be increased in size; the forearm is often enlarged at its lower third, especially just above and at the wrist; the wrist joint is almost always large. The hand, widened, thickened, and often lengthened, is massive and enormous, and appears heavy and cumbersome for the relatively small arm to carry. The ends of the metacarpal bones and phalanges are enlarged, giving prominent joints. The skin of the hand and the subcutaneous tissues are greatly hypertrophied, so that the normal lines of the palm are greatly deepened, even to the appearance of fissures in the flesh. At the upper part of the hand, and over the metacarpal bone of the thumb, and on the ulnar border, the hypertrophy of the soft parts is excessive.

The fingers, by the growth of phalanges and soft parts, become of the same width and thickness at the tips as at the bases, giving the appearance called "sausage-shaped," which is a characteristic feature of this disease.

FIG. 23.—Typical Hand in Acromegaly. (Author's case.)

The above-shaped fingers, with the great thickness of the soft parts over the metacarpal bone of the thumb and on the ulnar border of the hand, with the exaggerated palmar lines, and with the abnormal proportion of the hand to the size of the forearm, render the acromegalic hand a landmark not easily forgotten.

The fingers may appear somewhat flattened, and, according to Marie, there is often a swelling at the articulation of the first and second phalanges.

The nails are flattened, short, and sometimes widened, but always appear too small for the enlarged fingers, whose redundant flesh laps over them at the sides. There are strongly marked longitudinal striations, sometimes even with ridges, and there may be transverse striations on the nails. They are often brittle, breaking off or cracking easily, and in Cénas' case the nail of one finger fell off spontaneously and a new one developed.

Lower Extremity.—The thighs are generally not increased in size, although the condyles of the femurs are generally prominent and enlarged, which with the hypertrophy of the patellæ causes a marked enlargement of the knees. The upper ends of the tibiæ and fibulæ may or may not be enlarged, but the lower ends of the leg bones are generally found hypertrophied, causing prominent malleoli and large ankle joints. The tendo Achillis is frequently prominent and hardened, while the foot is described as "massive," "colossal," and "enormous." The bones of the feet are all enlarged, and especially the os calcis, which projects backward, giving a marked prominence to the heel. The foot is thick and broad, with a prominent cushion of thickened skin and subcutaneous tissue on the external border, a characteristic feature of the foot in acromegaly. The toes are all large, but more especially the big toe, which is immense, and crowds the other toes together. The skin of the foot is redundant, hypertrophied, and thickened, especially on the toes, causing them to appear pushed back and turned up, throwing the skin into great folds on the upper surface of the toes. The nails of the toes present appearances similar to those of the fingers.

The projecting os calcis covered with a cushion of hypertrophied skin and fat, the presence of a pad of hypertrophied tissue on the external border of the foot, the immense big toe pushing against the other toes, and the redundant skin, make the acromegalic foot as prominent a landmark as the hand.

Asymmetry.—Acromegaly is primarily a symmetrical disease, one part enlarging correspondingly with its fellow on the other side; but in many cases one side of the body is larger than the other, and the right half of the body is often the larger. In a number of cases data are given showing the growth to have begun in one foot or one hand, or in both feet or both hands, before any other parts of the body were affected.

In fact, the growth probably generally starts in the hands and feet, while later the face and lower jaw are attacked; then, the lower ends of the arm and leg bones; next, the crests, tubercles, ridges, and eminences show growth, and about this time kyphosis develops; while lastly cartilages and tendons all over the body show bone development. Besides the slight asymmetry of the two sides of the body, some atypical cases have occurred in which one or several toes or fingers were found to be larger than their fellows, or one side of the face and head was much larger than the other side.

Muscles.—At first the muscle growth and muscular power are increased, and sometimes the development of the muscles may be very great. Sooner or later, however, the muscles become atrophied in greater or less degree, and the muscular power is greatly diminished, even to the point of compelling the patient to remain in a sitting or reclining posture, or even forcing him to remain in bed. There may be intermittent attacks of great loss

of muscular power, to be followed by periods of improved strength.

The muscles of the arms and legs may become flaccid and shrunken, and some of the kyphosis and scoliosis may be due to muscular debility. Some of the muscles may be atrophied while others are hypertrophied, even to the extent of forming muscle tumors and causing deformity.

Skin.—The subcutaneous fat may be increased or diminished, but later it is generally found diminished, except perhaps on the diseased portions of the body. The skin on the affected parts is hypertrophied, and generally, especially where exposed, is olive brown or yellowish in color. This yellow color is most marked on the face, and here most noticeably on the eyelids. The face may, however, be pale, or the nose may be red, and the skin may be dry and harsh from diminished sebaceous secretion. There is frequently increased perspiration, coming on with slight exercise, or even without exercise, either general or local on the diseased portion of the body, and especially frequent on the legs. This perspiration may have a disagreeable odor. The growth of the hair all over the body is generally increased, especially on the legs, and on the head it is thick, strong, and coarse. There may be pigmentations on the skin, and growths of molluscum fibrosum frequently occur on the face, especially on the eyelids, and on the chest or back, and they are generally pendulous in character. Multiple fibromata of the skin may occur, of the size of a millet-seed, and fatty nodules may be found beneath the skin.

Blood-Vessels.—There are always vasomotor disturbances of the affected portions of the body, as shown by the tingling, flushing, and local sweating. The flushing is often accompanied by a "burning pain." Besides these signs, which denote the dilatation of the small blood-vessels, there is a marked tendency to a dilated and varicose condition of the superficial veins, which is frequently found on the legs. Hemorrhoids are often present, varicocele may be, and profuse epistaxis may occur, while the arteries may show signs of beginning atheroma.

The blood shows no marked or constant changes; the red corpuscles or the hæmoglobin may be decreased.

Internal Organs.—The lungs are normal, although there may be some dyspnœa, especially on exertion; it is due to the impaired respiratory movements of the chest.

The heart sounds are generally normal, but more or less hypertrophy is always present. Late in the disease dilatation occurs with its usual symptoms, dyspnœa, œdema of the lower extremities, palpitation, and perhaps systolic murmurs, and acromegalic cases die most frequently from sudden cardiac failure.

Physical examination does not discover much change in the size of the liver and spleen, though they may be found enlarged.

The kidneys, as interpreted by the examination of the urine, are generally normal, although albuminuria or peptonuria may be present, while polyuria is a frequent symptom. Glycosuria has been so many times present as to suggest some metabolic connection between pituitary disease and the disturbances of the sugar mechanism, and several cases of acromegaly have died of diabetes.

Sight.—The eyes may be normal, but are frequently affected, in all degrees from occasional flashes of light or eye blurs to narrowing of the fields of vision and atrophy of the optic nerves, even to absolute blindness. Exophthalmos is often present, due both to actual enlargement of the eyeballs and to bone growth in the orbital cavities, or perhaps to associated thyroid disease. The pupils are generally normal in size, but may be dilated, and the reaction is generally as usual, though it may be slow to light but normal to accommodation. Nystagmus, both rotary and vertical, has been present, and divergent strabismus has been noted in at least two cases. Narrowing of the visual fields has been found in all degrees, even to bitemporal hemianopsia, and signs of optic neuritis due to pressure may be found even before the vision is much impaired. Optic atrophy, partial or complete, of one or both eyes, is of frequent occurrence. The retinæ may show venous congestion, and the arteries may be small or they may appear pale, or a congestion as of a neuroretinitis may be present.

Hearing.—The hearing is not generally affected, but occasionally there has been decided deafness, and in several cases there has been continuous and unceasing tinnitus aurium, variously described as singing, ringing, rumbling, or swashing sounds. This ringing is often increased on lying down, so that the patient cannot sleep except in the sitting position, and anything that increases the blood pressure even momentarily will increase the tinnitus, and often give it a pulsating character. The drum membrane may be hardened and thickened, and so stiffened as to be immovable.

Smell and Taste.—These are but rarely affected.

Nervous Phenomena.—A most constant symptom is pain in the head, which may be referred to any region, but is generally frontal or vertical, and in one of the writer's cases was located in a small circumscribed spot, tender to pressure, over the region of the anterior fontanelle. This pain may be so mild that it is hardly complained of, or so severe, violent, and excruciating as to almost render the patient insane. The headache is often, like the tinnitus aurium, increased on lying down or by anything that increases the cerebral blood pressure. Pain is often present in the joints, especially the knees, and is often severe in the fingers. Pain is frequently complained of in the chest or abdomen, shooting around the body or confined to one side, or it may be lumbar or sacral. Almost every case of acromegaly has pain, more or less constant and severe, in some part of the body, often without any local cause. Crepitations may be found in some of the joints, which, of course, would account for the pain there, though there is no swelling or any evidence of acute inflammation. Pain sometimes seems to centre at one of the small fibromata which occasionally develop in the skin.

Sometimes a peculiar nervous sensation is complained of, a sensation as of a nervous discharge, or electric shower, starting from the top of the head and passing quickly over the body to the feet. This is sometimes described as giving the sensation of the rolling of shot; hence it has been termed the "shot feel."

There are no marked or constant paræsthesiæ in acromegaly, though slight numbness or prickling of the affected parts is often complained of, most frequently in the fingers. The tactile sense of the fingers may be impaired, so that small objects cannot be readily handled, and sewing, knitting, or even dressing becomes difficult. When this condition is present it may become much improved, though the growth of the body and the advance of the disease may continue; but of course there is always clumsiness in the use of the fingers from the size alone. Sometimes an intermittent vasomotor spasm in the fingers has been noted, causing localized anæmia with severe pain, while formication or hyperæsthesia of the hypertrophied parts may occur. More or less general numbness, anæsthesia, analgesia, or impaired perception of heat or cold, are rare conditions in this disease.

The electrical responses of the muscles and nerves are rarely found abnormal, and the reflexes, both deep and superficial, are generally unimpaired. Occasionally the patellar reflex is diminished, and rarely it is absent on one or both sides.

The mental faculties in the majority of cases are not affected, but the loss of memory, dulness or sluggishness of the mind, apathy or depression have all been recorded. Marie says that there may be a state of great good humor, but, on the contrary, melancholia is more frequent.

There may be great irritability, while there may be delusions, and the patient may be refractory and suspicious; he may develop decided insanity, and may even show suicidal and homicidal tendencies. This condition may be persistent or intermittent, or may last for a short time and not recur.

Another interesting condition which seems quite frequently to occur in acromegaly is a persistent drowsiness even to somnolency. This somnolency may become a

profound stupor that lasts for several weeks, does not seem to end in death, and may recur.

Vertigo may occasionally occur and be severe enough to cause the patient to grasp something for support. Attacks of syncope are sometimes a frequent symptom.

Pituitary Enlargement.—I believe that the pituitary gland is enlarged in every case of true acromegaly, but

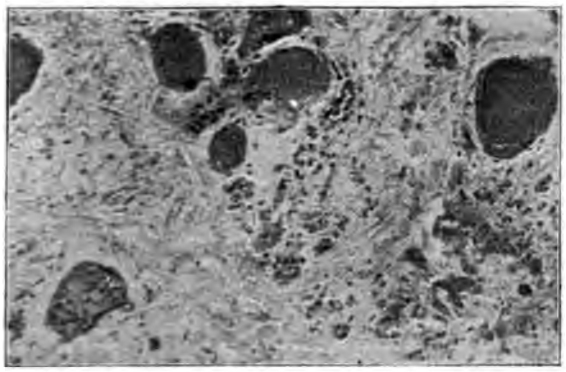

FIG. 24.—Section of Parenchyma of Thyroid Gland. Whole gland weighed 101 gm. (Author's case.)

it may not show evident signs of its growth. A positive sign of the enlargement of this body is the impairment of vision associated with a hypertrophy of the bones.

More than half of all cases of acromegaly show deranged vision or optic signs during some stage of the disease. The physical cause of the ocular disorder is largely the pressure of the growth on the optic chiasma. Where tinnitus aurium is constantly present there is either pressure on the cavernous sinuses by the enlarged pituitary or an actual growth into them of the pituitary tumor. It also seems probable that the conditions showing sudden and serious brain trouble, all of which point to cerebral tumor, are due to the first sharp pressure which the enlarged pituitary body exerts upon the brain, having perhaps suddenly burst from its bony moorings.

That in some cases one eye, in others both, and in still others the ears alone are affected can be explained by the condition of the bony environments of the sella turcica in the individual skull, the enlarging pituitary body tending to escape in the direction of the least resistance. If the middle clinoid processes are small, the pressure will be exerted correspondingly earlier on the optic commissure; or if one of these processes is smaller than the other, the pressure will first be exerted on that side, and but one eye may be affected.

PATHOLOGICAL ANATOMY.—*Pituitary Body.*—In autopsies on cases of acromegaly the pituitary body has been found normal so few times that I question the diagnosis in those cases. I believe that an enlarged or diseased pituitary body is always present in cases of true acromegaly. The enlarged hypophysis may be a normal hypertrophy, an adenoma, a glioma, or a small-celled growth resembling sarcoma, and there may be cystic, colloid, or granular degeneration. Frequently this enlargement or tumor growth has been confined to the anterior lobe of the hypophysis, the prehypophysis.

Thyroid.—The thyroid gland is probably generally abnormal in acromegaly. It may be hypertrophied and give a hypersecretion and all of the symptoms of exophthalmic goitre, or it may be atrophied and cause some myxœdematous symptoms, or, which is probably most frequently the case, the gland is first hypertrophied and then connective-tissue growth displaces the glandular parenchyma, and though the gland is actually enlarged, it is producing a diminished secretion, and a partial myxœdema occurs. This accords with the symptoms of a long-continued acromegalic case, and with the frequent autopsical finding of an enlarged and heavy thyroid gland which, in my case at least, contained a greatly diminished amount of iodine. This gland may also show cystic degeneration. In the writer's case a large supernumerary thyroid gland was found in the upper part of the thoracic cavity, which contained a large amount of iodine.

Thymus.—The thymus gland has not been often mentioned, but several times it has been found enlarged, and in one instance a fatty growth in the region of the thymus has been reported. In these cases instead of thymus glands they may have been supernumerary thyroids. A thymus gland contains no iodine (Mendel).

Another interesting disturbance of the metabolism of the body in this disease is shown by the number of times that sugar has been discovered in the urine.

Brain.—The brain has frequently been found enlarged, but may not be, even in cases which show almost every other organ of the body to be enlarged. This enlargement of the brain seems to be due to a general growth. An increase of the neuroglia cells has been found, but in direct proportion to the general enlargement of the brain substance.

The growth of the pituitary body not only causes enlargement of the sella turcica, but may cause symptoms of pressure with referred pains, paralysis, cerebral irritation, insanity, or even coma. If the bony formation of the sella turcica allows the enlarged pituitary body to press upon the optic commissure, we find pressure atrophy of the optic nerve; or a tumor growing in the sella turcica may press laterally and interfere with the blood flow in the cavernous sinuses, or even in the internal carotids, or may even grow into the walls of the sinuses, causing impaired blood flow in them and a constant tinnitus in the ears.

The pineal gland has been found double its ordinary size, and little tumor growths have been found attached to the base of the brain.

Calcified and even ossified plates have been found in the dura mater, and its attachments to the skull have been found ossified. The arteries at the base of the brain have been found enlarged and thickened, often especially marked in some one artery in the circle of Willis, while another artery or another part of the same artery may be distinctly narrowed. The arteries may become distorted and tortuous, and the posterior cerebral has been found knotted and imperforate. The cranial nerves have been found both normal and enlarged. The nerve changes in the brain and cord, if there are any, are probably secondary to the vascular changes. As in this disease we find the blood-vessels almost constantly changed, either narrowed, due to a thickening of the intima, or dilated, due to a thinning of the other coats, we may expect to find all kinds of changes due to a greatly modified blood supply, be it in an organ or in nervous tissue.

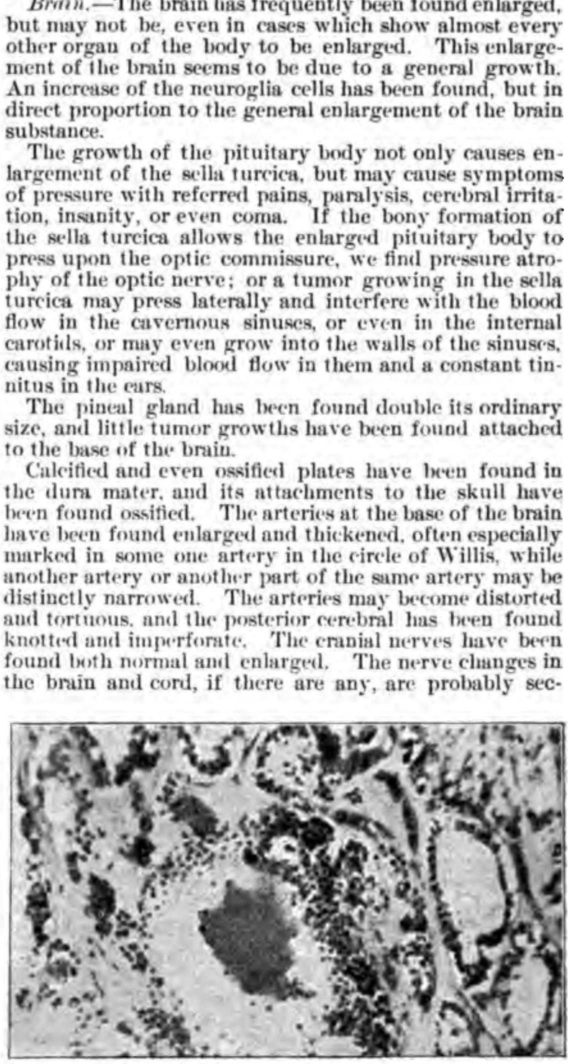

FIG. 25.—Section of Thoracic Thyroid Gland. Whole gland weighed 36.5 gm. and contained a large amount of iodine. (Author's case.)

Spinal Cord and Nerves.—The medulla and spinal cord are generally normal, but the pia of the cord has been found thickened, and some of the columns of the cord have been found degenerated. Probably, however, as

above stated, all nerve degenerations of the brain or spinal cord are due to foregoing vascular changes.

The nerves of the body, and especially of the extremities, may be enlarged generally, this change being due to an increase in the interstitial connective tissue. They may show sclerosis in some places and fatty changes in others, and the vessels of the nerves and spinal cord

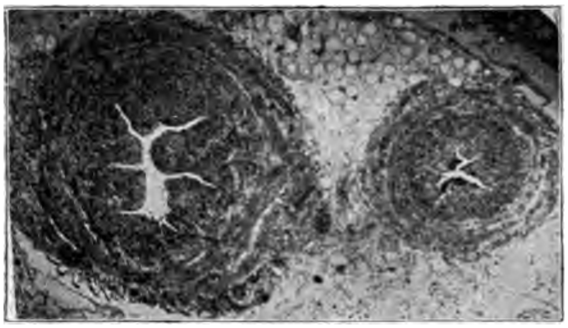

FIG. 26.—Section of Arteries of the Leg Near the Posterior Tibial, Showing Thickened Intima. (Author's case.)

may show hyaline degeneration. The ganglia of the posterior roots are often enlarged from an increase in the connective-tissue elements.

The ganglia and nerves of the sympathetic system show no special changes, though they may be enlarged, and from the same cause as in the case of the spinal nerves, viz., from connective-tissue growth.

Heart.—The heart is probably always enlarged in acromegaly, by reason of an actual hypertrophy, especially of the left ventricle; this being due to the increased work which it must perform in overcoming the resistance offered by the thickened blood-vessels. The heart may become enormous, and in my case it weighed forty-one ounces. Also the pericardium and endocardium may be increased in thickness, and there may be an increase of fibrous connective tissue between the muscle fibres. Later the heart, though hypertrophied, becomes weakened by the impaired action of its muscle fibres due to this connective-tissue formation or perhaps to the presence of fat globules, or else to the impaired blood supply of its walls, which in turn is due to thickening of the intima of its own nutrient blood-vessels.

Blood-Vessels.—I believe the vascular changes to be a constant feature of acromegaly, the intensity of these changes or the localization of the most marked changes in the blood-vessels causing the many variations of symptoms or conditions seen in different cases of acromegaly.

More or less generally all over the body the coats of the arterioles are thickened, and generally it is the intima which is the most affected. This may also be true of the veins, although in many places the vein walls seem to be thinned, allowing varicose conditions to take place. This may occur in the lower extremities, or as hemorrhoids, or in the large veins of the arms and neck. The epistaxis noticed in some cases is probably due to this weakening of the blood-vessels.

The blood is normal, or late in the disease it may show simple anæmia.

Lungs.—The lungs are probably not often affected, but many times, both in autopsical reports and in clinical accounts of cases of acromegaly, "phthisis" has been mentioned, or tuberculous consolidation has been found. Chronic bronchitis, œdema, or passive congestion can develop from a weak heart action in the later stages.

The Digestive System.—The stomach and intestines present no specific abnormalities. The pancreas often shows changes, especially in those cases in which glycosuria has been present.

The liver is probably generally enlarged, sometimes very greatly, and may show a great increase in connective-tissue growth; in other words, it is an hypertrophic cirrhosis. There may be a passive congestion or fatty degeneration of the liver.

The spleen may be enlarged by passive congestion and an increase in its connective tissue.

Genito-Urinary System.—The kidneys are often found diseased (chronic nephritis), or they may be cystic. The kidneys and suprarenal capsules are often found increased in size.

Microscopical examination of the genitals shows an increase in connective-tissue growth and even at times the formation of fibrous tissue; these changes being accompanied by a gradual diminution of all functional activity.

Skin.—The skin is hypertrophied over the affected portions of the body, sometimes in a marked degree. This is especially true of the scalp, hands, and feet, all of the layers of the skin taking part in this thickening. The sweat glands may have a double layer of epithelium. Fibromata, neuromata, and elephantiasis of the skin have been observed, and molluscous growths are of frequent occurrence.

The subcutaneous fat may be increased or decreased in thickness, but in the later stages it is probably nearly always decreased.

Muscles.—Many of the muscles at the time of death, unless the patient dies early in the disease from some intercurrent affection, are found atrophied, and yet there may be many local hypertrophies. Certain muscles, especially the deltoid or the supraspinatus, may become greatly hypertrophied, forming veritable muscle tumors.

One side of the body, most frequently the right, may be larger than the other, both in the size of the bones and in the bulk of the soft parts, more especially the latter.

Skeleton.—A considerable number of acromegalic skeletons have now been carefully studied, and it is found that in well-marked cases nearly all of the bones of the body are enlarged, although a few individual bones may not take part in this increased growth. Of course the bones of the extremities are the ones most evidently enlarged, still I cannot believe that these are more apt to be enlarged in true acromegaly than are the bones of the body. The long bones undoubtedly show the greatest enlargement and growth at their extremities, which fact seems to me to be due to the tendency of articular cartilages to ossify and to become co-ossified with the articular surfaces of the bones; still in many instances the shafts of the bones are also decidedly enlarged. The spongy bones of the skeleton are all more or less thickened, and all articular surfaces, whether of long or spongy bones, show a tendency to spread out, widen, and grow more prominent. The flat, thin bones, while increasing in extent show a tendency to become thinner in their plates. This is not true of the cranial bones, because the spongy tissue in the diploë increases in thickness. We sometimes find at the ends of the long bones, just back of the articular surfaces, a thinning of the bone, while they are at the same time extending their articular surfaces. This growth of bone is a hypertrophy, the new bone growing from the periosteum and also within the medullary spongy tissue at the ends of the long bones. In the early part of the disease this growth seems to be more especially confined to the periosteum; later the apophyses and epiphyses become affected.

The crests, tuberosities, and eminences are enlarged and grow in the direction of the muscular action. This seems to me to be due to the fact that a portion of the tendons of the muscles become ossified and co-ossified with the bone. This condition is so prominent at the articular surfaces that I think the same thing must be true of the ridges and tuberosities to which the muscles are attached. The tendons of the muscles are often found in deep grooves or bony canals, and the foramina for the nutrient arteries, and especially for the articular arteries, are often enlarged.

PLATE V

FIG. 3.

FIG. 1. FIG. 2. FIG. 4.

ACROMEGALIC SKELETON—(OSBORNE'S CASE)—AT THE YALE MEDICAL SCHOOL

[EXPLANATION OF PLATE]

FIG. 1.—Normal skeleton.

FIG. 2.—Skeleton of Acromegaly showing Kyphosis, enormous antero-posterior diameter of thorax, great obliquity of the ribs, long arms reaching almost to the knees, large feet, great projecting os calcis, etc. (author's case).

FIG. 3. Spine of Fig. 2; shows co-ossification of bodies of dorsal vertebræ and many bony unions of spinous and transverse processes.

FIG. 4.—Skull of Fig. 2, showing enormous inferior maxilla, prognathism, projecting supraorbital ridges, large and prominent molar bones, etc.

Osteophytes may be found in the joints, especially over the wrist and ankle joints, or pieces of calcareous material may be found loose in a joint. The spongy ends of the long bones may become more compact, through eburnation and a change in the architecture of the part. The ends of the bones in some cases have shown condensing osteitis. This laying on of bone at the extremities, the articular surfaces, may lengthen a long bone without the shaft being at all affected.

Before critically surveying the individual bones in any particular patient dying with this disease, the duration of the case must be considered, as the longer the patient has lived with this disease the more decided will be the growth of a bone and the irregularities which it manifests.

Head.—The bones of the cranium are always more or less thickened, this change being due largely to an increase of the diploë, while the external and internal plates may be thicker than normal, or even thinner and softer than usual. The ridges and crests for the attachment of the muscles and fasciæ are more prominent, while the occipital protuberance has been found as a spicula-like outgrowth, an exostosis. The parietal eminences are sometimes abnormally prominent, as are always the superciliary ridges, the latter condition being due not only to dilatation of the frontal sinuses, but also to the thickening of the plates of the frontal bone in this region. The sphenoidal sinuses may be enlarged and pushed forward by the growth of other parts of the sphenoid, and the antrum of Highmore is probably always enlarged. Thompson found the margin of the foramen magnum surrounded by irregular protuberances of spongy bone. The sella turcica is always enlarged and deepened, probably because the enlargement of the pituitary body causes the surrounding bone to undergo absorption

The lengthening of the face is largely due to the increase in the vertical diameters of the superior and inferior maxillæ. The maxillary bones and the sphenoid bones contribute the principal part of the total enlargement of the bones of the skull.

Many of the sutures of the cranium and of the face are obliterated by complete co-ossification. The enlarging malar processes, orbital processes, and nasal processes of the superior maxillary bones cause the pushing outward of the malar bones, the lateral widening of the orbital cavities, and the pushing upward of the nasal bones respectively; thus causing the prominence of the malar bones, the quadrilateral appearance of the orbital cavities, and the wide nasal openings seen in skulls of acromegaly.

The external auditory canals may be increased in length, and are often encroached upon by bony growths which spring from their walls. The styloid processes may be greatly elongated by ossification of their tendons. The glenoid cavities are increased in size, probably due to the large size of the condyles of the lower jaw.

The lower jaw is massive, the chief growth being in the body, which is found lengthened and widened, especially at the symphysis, while the mental process stands out with undue prominence. The alveolar process is widened and thickened, and the rami also may take part in the growth, while the angle formed by the junction of the body and the rami becomes more obtuse, often to a marked degree. The coronoid processes are often greatly enlarged. The growth of the alveolar process is rarely participated in by the teeth, they remaining normal in size, so that while the alveolar cavities undergo enlargement we frequently have spontaneous falling out of the teeth.

The hyoid bone may be enlarged with all of its ridges very prominent, and the laryngeal cartilages may also be enlarged.

Though the projecting lower jaw (prognathism) may not have been observed in a few undoubted cases of acromegaly, still the presence of this characteristic feature, in combination with actual bone enlargement of the hands and feet, is clinically, I believe, pathognomonic of this disease.

Spine.—Marked changes are always found in the spine, the degree being due to the age of the disease. The bodies of the vertebræ are enlarged, especially from the laying on of bone on the anterior part in the cervical and dorsal regions. The increase of bone is often restricted to the upper part of the interarticular cartilages, while in the lumbar region the increase of the bone is more general.

The irregular thickening of the intervertebral cartilages, with the irregular growth of the bodies of the vertebræ, sooner or later causes deformities of the spine, namely, kyphosis, lordosis, or scoliosis, or more than one deformity. An absorption of the intervertebral discs, especially on the anterior borders, with co-ossification of the anterior parts of the bodies, and ossification of the

FIG. 27.—Skiagraph of Part of Acromegalic Hand, Showing Hypertrophy of the Soft Parts and the Increase of Spongy Tissue at the Ungual Ends of the Distal Phalanges. (Author's case.)

anterior ligaments, which often occurs, may cause an enormous kyphosis, the anterior part of the spine appearing, under these circumstances, as if formed of a single bone.

The transverse processes probably always are enlarged, and may be joined together by the ossification of their connecting ligaments. This ossification may take place along the interspinous ligaments, or we may find ossification of the posterior intervertebral ligaments. The lumbar vertebræ are sometimes of great size, and the sacrum may have its lateral masses much enlarged.

Thorax.—The sternum is enlarged and thickened, and the ensiform cartilage is ossified and generally projects

outward. Large transverse ridges are often found on the sternum; also a hollow or depression may be seen at the upper part, due to the manubrium not enlarging relatively as much as the body of the sternum.

The costal cartilages are large and more or less ossified, and often show prominent cartilaginous or bony nodes at their points of junction with the ribs, thus simulating the rachitic rosary. The ribs are wide and thick, and by the faster growth of the costal cartilages they become abnormally oblique, while the sternum itself is pushed forward, giving an enormous antero-posterior diameter to the chest.

Upper Extremity.—The clavicles are always found enlarged, often enormously so, most marked at their extremities, and especially at their sternal ends. Their ridges and tubercles are very prominent.

The scapulæ are generally found enlarged, especially in their transverse diameters, and the spines may be enormous in size. The glenoid articular surfaces are often enlarged, through the ossification of the glenoid ligaments.

The articular surfaces of all of the long bones are enlarged, due to ossification of the articular cartilages or ligaments, and they are often roughened. There may be exostoses, spongy growths, osteophytes, or calcareous deposits in and around the joints.

The humerus is frequently not enlarged, though its extremities, especially the head, may be.

The radius and ulna, if the case is of long standing, are found enlarged, especially at their articular surfaces, and more especially at their lower extremities. As previously stated, the ridges and protuberances of all the bones are enlarged and prominent.

The carpal bones are probably always more or less enlarged, and may all be very markedly so. The metacarpal bones and phalanges are widened and thickened; the former especially at their heads, and the latter at each extremity, thus rendering the joints prominent. The distal phalanges are generally the most affected, and may show an increase of spongy tissue at their ungual ends.

Pelvis.—The pelvis is always enlarged, with the symphysis of the pubic bones often wide and deep, while the crests of the ilia are wide apart, by reason of a spreading out of the ilia. Though the pubic bones and the iliac bones may be enlarged, with their ridges and eminences increased in size, and with the obturator foramina enlarged, the substance of the bones themselves may be considerably thinner than normal. The acetabular cavities are often enlarged and roughened by partial ossification of the cotyloid ligaments.

Lower Extremity.—The femurs may be enlarged at both extremities, as may also be the heads of the tibiæ and fibulæ.

The patellæ are often enlarged and may present abnormal spinous processes.

The malleoli are frequently found enlarged. All of the tarsal bones may be enlarged; especially is the os calcis often enormous in size, on account of the laying on of bone at the attachment of the tendo Achillis.

The metatarsal bones and the phalanges of the toes are all enlarged similarly to the hands. Thompson found several of the phalanges of the toes ossified together. The distal phalanges may show spongy enlargements at both extremities, and there may be spongy spiculæ of bone which reach around from one extremity to the other, forming foramina or incomplete notches on the sides of the bones.

ETIOLOGY.—The question as to the cause of this disease is a very important and interesting one, and various theories have been advanced.

Freund suggested the probability that acromegaly was a disease of puberty, *i.e.*, a disease of development, a possible returning to type, the large hands and feet, projecting jaw, and retreating forehead being certainly very suggestive. He said that this anomaly of development had some relation to the condition of the developmental organs, to sexual development, and that the early cessation of menstruation or early loss of sexual power caused acromegaly.

This theory is not supported by facts. In the first place, two-thirds of all cases develop after the age of twenty; and while the cessation of menstruation is unquestionably an early and a very frequent symptom, it is not constant, and is only a symptom, and the loss of sexual power in the male is a gradual loss, diminishing with the progress of the disease. I believe these phenomena are only symptoms, and I cannot attribute to them, as does Freund, a causative relation to this disease.

Sex does not seem to bear any special relation to the disease, though the records show a few more men to have been attacked than women. Nativity plays no important part in the causation of acromegaly, and probably no race is exempt. Heredity does not seem to be a tangible factor, and no foregoing disease or condition is known to predispose or to cause acromegaly.

The Klebs theory that the disease is due to angiomatosis, and that its seat is in the vascular system, though having its supporters, I believe not to be founded on fact. That there is thickening of the walls of most of the blood-vessels and that there is a thinning of the walls of some blood-vessels, giving rise to hemorrhages and varicose veins, there is no question. Also that there is a vasomotor ataxia is unquestionable. It is a fact, furthermore, that we have enlargement of some of the blood-vessels supplying hypertrophied tissue; but that there is an actual new growth of blood-vessels in this disease is, I believe, not true.

The theory of Von Recklinghausen, that this disease is of neurotic origin, is, I believe, incorrect. Lancereaux believes it to be a trophoneurosis. That we have nearly all kinds of neuroses and vasomotor and trophic disturbances is true, but that the origin is not in the nervous system but in the ductless gland system, I am firmly convinced.

The thyroid and thymus glands have come in for their share of interest as being the supposed cause of this disease.

While I do not believe that puberty or disturbed conditions of the genital system have anything to do with causing this disease, still I believe that Freund struck the keynote when he claimed that acromegaly was a disease of development. The majority of cases can be traced as beginning in the decade of life between twenty and thirty years.

In the beginning this disease is closely allied to gigantism, and I believe a disturbed condition of the pituitary body to be the cause of both conditions. I believe that gigantism in its perfect development to be due to a normal hypertrophy of the pituitary gland, *i.e.*, a hypersecretion occurring at the age of puberty or age of general and symmetrical body growth and development. I believe that in its incipiency the disease of acromegaly is primarily a hypertrophy of the pituitary body, causing a condition of beginning gigantism. Earlier in some cases, later in others, this normal hypertrophy of this gland becomes a pathological condition—either a new-growth formation, or a cyst formation, or both. At this time the symptoms of acromegaly due to disordered secretion from the pituitary will begin to appear and will grow more typical the longer the patient lives.

I believe that gigantism will remain such as long as the pituitary body is in normal hypertrophy, but that these cases of gigantism will assume later an acromegalic type, if, as is often the case, the pituitary body begins to take on pathological conditions. In other words, I believe that an excess of normal secretion from the pituitary gland is the cause of gigantism, while perverted secretion from it is the cause of acromegaly.

When the pituitary body becomes diseased in these acromegalic cases it seems that very frequently, perhaps almost invariably, the thyroid gland becomes enlarged and attempts to do some of the work which the pituitary is now unable to do. If the thyroid is much enlarged we have added to the condition of true acromegaly the conditions present in exophthalmic goitre, namely, exophthalmos, irregular nervous heart, profuse sweating, etc. If the thyroid—and it is this gland which most frequently at-

tempts to assist the pituitary body in its lost function—becomes atrophied or degenerated and does not furnish its normal secretion, we have a greater amount of hypertrophy of the soft tissues, that is a myxœdematous condition added to the condition of true acromegaly. Just what relation a persistent thymus gland (if the cases of reported persistent thymus glands be thymus glands and not thoracic thyroids) bears to the thyroid gland we are not yet able to state.

My own case proves that an auxiliary thoracic thyroid containing a large amount of physiological iodine can develop sufficiently to assist an incompetent thyroid gland.

To sum up my interpretation of the causes of the conditions present in acromegaly:

1. I believe the primary cause of acromegaly to be due entirely and alone to a disordered secretion of the pituitary, this disordered secretion either allowing or promoting a general connective-tissue increase all over the body, and an irregular normal hypertrophy and body growth; in other words, this gland normally has a secretion or elaboration which has something to do with the growth of the body.

2. Next, we find the thyroid attempting to furnish some new secretion, and at the same time a large amount of its own, to assist the pituitary body. Its hypertrophy, however, soon becomes pathological by connective-tissue formation, and the gland does not furnish proper thyroid secretion. We now have symptoms of partial myxœdema with enormous hypertrophy of the soft parts, especially over certain portions of the extremities, and from an enlarged thyroid we may have pressure symptoms and exophthalmos.

3. All of the other symptoms of acromegaly are due to the pressure of the enlarged pituitary, or to connective-tissue growths in the organs of the body, or to growth of the bones.

DIAGNOSIS.—This disease must be diagnosed from myxœdema, gigantism, erythromelalgia, elephantiasis, leontiasis ossea, chronic rheumatism, syringomyelia, rachitis, osteitis deformans, arthritis deformans, pulmonary hypertrophic osteo-arthropathy, local hypertrophies, and adiposis dolorosa.

More than one case of acromegaly has been described under the name of *myxœdema*. Myxœdema is an affection associated with an increase of the subcutaneous fat and connective tissue, and is characterized by a mucoid deposit in the skin. There is swelling of all parts of the face, tongue, throat, and larynx, but generally there is no pitting. The hands become large and clumsy, and there may be pain in the joints and head. There may be loss of hearing, choked disc, and impaired mental faculties, even to dementia in the last stages.

The principal clinical differences between these two diseases are as follows:

Myxœdema.	*Acromegaly.*
1. About eighty per cent. of all cases are women.	1. Both sexes are about equally affected.
2. Occurs most frequently between the ages of forty and fifty.	2. Begins most frequently between the ages of twenty and forty.
3. Bones are never enlarged.	3. Bones are always enlarged.
4. Face is round and full.	4. Face is oval or elliptical.
5. The ends of the fingers are swollen and clubbed.	5. The ends of the fingers are of the same size as the bases, *i.e.*, they are "sausage-shaped."
6. The skin is pale, waxy, puffy, boggy, and shiny.	6. The skin is yellowish, wrinkled, and hairy.

Gigantism, or giant growth, is distinguished from acromegaly by the fact that in the former there is symmetrical and general growth all over the body; the cranium grows as much as the facial bones, and the face does not look too large for the head, nor the head too large for the body, as is the case in acromegaly.

In gigantism the ends of the bones are not enlarged out of proportion to the size of the shaft, and the hands and feet are not enlarged out of proportion to the arms and legs. The bones increase in length as well as in width and thickness, and that symmetrically, and the whole growth of the body is in proportion, as in a normal individual, all of which is quite the contrary of what is observed in acromegaly.

In gigantism there is no projection of the lower jaw, there are no nervous phenomena, there are no eye and ear symptoms. The nose, ears, lips, and tongue are not increased in size out of proportion to the size of the head, face, and mouth.

In *erythromelalgia*, a vasomotor neurosis of the extremities, there may be some increase in the size of the hands and feet with severe pain, and there is always an impaired blood flow, giving burning sensations, local redness, and even cyanosis, often in patches or spots. Cênas' case, with its peculiar pigmentation, is the only case of acromegaly that has markedly simulated erythromelalgia. In the latter disease, however, there is no enlargement of the bones or soft parts of the face, no eye symptoms, no marked change in the speech, and the hand itself is unlike the acromegalic hand; the fingers are not sausage-shaped, but smaller at the tip than at the base.

Elephantiasis Arabum is a hypertrophic disease of the skin and subcutaneous tissue, located generally in one, occasionally in two extremities of the body. There is generally a history of several attacks of local inflammation of the part affected, followed by a continuous growth and hypertrophy of the skin, until an enormous size is reached. The hypertrophied skin falls in great folds, fissures form, and the part becomes one immense, homogeneous mass, without form or shape, and sections show a fibrous tissue without nerves or blood-vessels.

How different is this picture from that of acromegaly, where all of the extremities are enlarged, or at least one after the other, and the parts never lose the normal curves, prominences, and hollows, and, though large, preserve their normal contours.

Again, in elephantiasis the bones are not enlarged, the skeleton is not affected, and the nervous, facial, and cerebral phenomena of acromegaly are not present.

Leontiasis ossea is the name given by Virchow to the condition in which osteophytes, or bony tumors, are formed on the face and cranium. These bony tumors are of irregular distribution, and produce great deformity and asymmetry. There is no hypertrophy of the limbs. Though this disease has been several times mentioned in the diagnosis of acromegaly, I fail to see how it could be confounded with the general constitutional disease of acromegaly with its manifold signs and symptoms.

During the first stages of acromegaly one of the frequent symptoms, and often a prominent one, is joint pain, which at this stage might lead one to mistake the disease for *chronic rheumatism*. The joints at this time are tender to the touch, but are not reddened or swollen. The pain is not permanent in any one or two joints, and ankylosis does not take place, although later crepitations are often present, and some contractures of the fingers may be found, as in Cênas' case, due to the flexor tendons not growing as rapidly as the bones. As soon as the hands, feet, or face begin to enlarge, the diagnosis from chronic rheumatism becomes plain.

Syringomyelia is a disease of the nervous system which generally begins before twenty, or in early adult life, and in its slow development and long duration simulates acromegaly. After the complete development of either disease, however, "the amyotrophic paralysis, with retention of tactile and loss of thermic and painful sensation" (Osler) in the case of the syringomyelia, and the enlarged extremities, the formation of the face and chest, to say nothing of the signs of pituitary enlargement, in the case of the acromegaly, render the diagnosis easy. Several cases of acromegaly have shown coincident symptoms of syringomyelia, and autopsical examinations have revealed gliomata in the spinal cord.

Rachitis is a disease of childhood, or rather babyhood, occurring most frequently in children under three years of age. This alone would exclude the possibility of con-

fusion with acromegaly, except in congenital cases. Rickets is pre-eminently a disease of impaired bone formation, as manifested by the slow eruption or entire absence of the teeth and by the impaired growth or softening of the bones; while acromegaly, on the other hand, is pre-eminently a disease of increased bone formation.

The ends of the bones, especially the epiphyses of the wrist, unquestionably are enlarged in rickets, while the hands and feet may be flattened and apparently widened, but there is no increase in the thickness of the hands or feet. The bones of the head show no malformation, except flattening and lengthening of the cranium with projection of the occiput and the softened spots. This causes the cranium in rickets to appear too large for the face, while in acromegaly the face appears too large for the cranium.

Also in rickets we find deformities of the pelvis, and if the child creeps, deformities of the arm bones, and if he walks, bending of the leg bones. This is quite different from acromegaly, in which we have widening, hardening, and general growth of the bones. Softening of the ribs causes a sinking in just before the junction with the cartilages, giving the formation of the rachitic rosary, which from another cause we also find in acromegaly. Kyphosis, when it occurs in rachitis, is in the dorsal region, while in acromegaly it is almost invariably in the cervico-dorsal region. It is thus seen that it is hardly possible to confound the one disease with the other.

The diagnosis between the *osteitis deformans* of Paget and acromegaly is generally not difficult.

The following schedule shows some of the marked differences:

Osteitis Deformans.	*Acromegaly.*
1. Rarely occurs before fifty, never before forty years of age.	1. Very generally begins before forty years of age, almost never after fifty.
2. The long bones are the ones primarily affected; rarely are the hands or feet affected.	2. The hands and feet are enormous; long bones are generally not much affected.
3. The long bones are often curved, giving great deformity.	3. The long bones are normal in shape, possibly thickened at the extremities, but are never curved.
4. Often one limb or one bone is affected long before another limb or bone.	4. The hands, feet, arms, and legs are generally nearly symmetrical.
5. The cranial bones are affected, rarely the facial.	5. The facial bones are affected, rarely the cranial.
6. The lower part of the face is narrow, giving it a triangular appearance.	6. The lower part of the face is broad, giving it an elliptical appearance.

The above gross differences, to say nothing of the more minute ones, will generally render easy the diagnosis of osteitis deformans from acromegaly.

Arthritis deformans, perhaps, approaches more nearly than any other bone disease to the external conditions found in acromegaly. In arthritis deformans decided changes take place in the articular tissues, and are accompanied by pain, with sooner or later great deformity and ankylosis of the joints. Tender nodules may appear in the muscles, while the muscles themselves become atrophied. The disease is apt to attack the same joints on both sides of the body symmetrically, but soon spreads to all of the joints. The hands are thin from the wasting of the fat and muscles, but the ends of the phalanges and metacarpal bones may be enlarged and nodular. The fingers are more or less flexed and turned toward the ulnar side of the arm, while the joints of the hand are all stiff and more or less completely ankylosed. How different is this condition from the acromegalic hand!

Within the joints bony or cartilaginous protuberances are found on the outer surface of the epiphyses in arthritis deformans, while in acromegaly we may find osteophytes at the ends of the bones, or bony growths in the joints. Aside from this similarity in the joint lesions these two diseases show no agreement of symptoms or appearances. The hypertrophy of the soft parts of the hands and face, with the enlargement of the bones of the face, with the cervico-dorsal kyphosis, enlarged tongue, changed voice, and signs of pituitary enlargement, will all or any of them render the diagnosis from arthritis deformans easy.

Schulz has reported a case of acromegaly associated with arthritis deformans.

The condition known as *pulmonary hypertrophic osteo-arthropathy* must be carefully separated from acromegaly, as it simulates the latter disease by causing an enlargement of the hands and feet. This osteo-arthropathy is subsequent to, or consequent on, some affection of the lungs, which may be a bronchitis, an empyema, or perhaps most frequently some new growth located primarily or secondarily somewhere in the respiratory tract.

The hands are enlarged, but principally in the joints and the ends of the fingers, the middle of the hand not being attacked. The elbow, shoulder, and knee joints are all affected, and there is always more or less impaired motion. The wrist joint is large, the hand proper not much enlarged, while the fingers are increased in size, especially the last phalanx, but the soft parts are not hypertrophied. The appearance of the finger nails is also quite characteristic of this disease. They appear too large for the fingers, spreading out at the sides, and even curving over the ends of the fingers, often giving the appearance of the beak of a bird, while the enlarged ends of the fingers have caused them to be likened to "drumsticks." Turning to the acromegalic hand, with its immense thickening of the hand proper, hypertrophy of the soft parts, equally enlarged phalanges, sausage-shaped fingers, small nails, much too small for the fingers, one might make the diagnosis by the hand alone. The bones in pulmonary hypertrophic osteo-arthropathy are enlarged, but not the soft parts, while in acromegaly both are enlarged. In the former disease dorso-lumbar kyphosis may be present, while in acromegaly the kyphosis is cervico-dorsal.

The feet and toes in this disease are affected similarly to the hands. The face presents a different appearance from that of acromegaly; it is more rounded, the lower jaw is very rarely enlarged, prognathism does not occur, the face appears small, the soft parts are not hypertrophied, and the lips and tongue are normal in size.

Local hypertrophies are not instances of partial acromegaly. These local enlargements of one extremity, or one finger, or one toe are generally congenital, though they may increase in size at the time of puberty. One side of the face may be affected, involving the bones and soft parts, including the tongue, tonsil, and palate on that side, but whatever the enlargement there is no symmetry.

One more disease remains to be diagnosed from acromegaly, viz., *adiposis dolorosa*. This disease is characterized by an enormous deposit of fat, first in the form of nodules, either in one location or in corresponding places on the upper or lower extremities. These deposits soon cause pain, diminished sensibility, and muscular weakness, and the muscles may show the reaction of degeneration. The absence of any marked enlargement of the hands, feet, and face, as well as the absence of increased bone growth, excludes confusion with acromegaly.

PROGNOSIS.—The duration of acromegaly is variously estimated from ten to twenty years. The patient may die of some intercurrent disease, or may live for years with but a slow progression of the disease, but no case of complete recovery has yet been reported.

This disease is one of continuous progression, especially in the growth of the bones. Under treatment, or without treatment, periods of apparent quiescence or periods of cessation of symptoms occur, and the soft parts of the hypertrophied portions of the body not only may not enlarge, but may actually appear to be diminished in size. Yet even in such cases the bones apparently continue to grow.

These periods, when the patient may say that he feels well, are sooner or later followed by marked exacerbations of all the symptoms, often coming on suddenly. These symptoms, all of which may be ameliorated by treatment, are severe headache, often dizziness, obstinate constipation, troublesome dyspepsia, aggravated eye or ear symptoms, great temporary loss of strength,

and melancholia, with more or less pain referred to various parts of the body. At this time the soft parts on the hypertrophied portions of the body appear larger, although œdema may not be found.

A more or less complete recovery from these exacerbations, or severe symptoms, generally occurs, but the patient is not quite as well in all respects as he was before. Thus the disease proceeds, with some symptoms more or less constant, until there is hardly a tissue or organ of the body that is not affected in greater or less degree.

Finally, little by little the patient falls into a condition of progressive cachexia, with partial or nearly complete loss of muscular power, due to atrophy of the muscles, so that he may be compelled to remain in bed. This condition may last for several years, and then death occurs unexpectedly and suddenly from syncope.

It is possible that an enlarged pituitary body may cause coma and death. Most cases of acromegaly, however, die of some intercurrent affection, the most frequent of which are cardiac disease, nephritis, or diabetes, all of which are the results of the connective-tissue hyperplasia of the involved organs, viz., heart, kidney, and pancreas respectively.

The headache and cerebral disturbances may become so severe as to cause suicidal tendencies, and temporary insanity may occur, probably caused by pressure from an enlarged pituitary body.

TREATMENT.—This disease is incurable, but in any given case we can safely expect to ameliorate many of the nervous symptoms. When there is an exacerbation of symptoms, of all treatment rest is the most important, under which all the phenomena, except those produced by actual lesions, will improve. Pain, the most frequent cause of complaint, has been variously treated by all of the analgesics, but with only temporary and varied success. The bromides are often of service in relieving the headache and the feeling of pressure in the head.

The constipation should be treated, while dyspepsia, when present, can be best helped by a diet that requires but little mastication, as prognathism, which is so frequently present, is one constant cause of the dyspepsia.

Positive impairment of sight or hearing cannot be improved, and if the sight is affected at all the loss of vision will probably increase. Tinnitus aurium, if due to this disease, can probably be but little, if at all, helped.

Any tonic or bracing treatment, combined with rest, will often cause a cessation of the acute symptoms and an apparent pause in the disease, except in the last stages.

If there is atrophy of the muscles and great loss of muscular power, strychnine, given by the mouth or hypodermically, is of value, especially when combined with faradism.

Cardiac insufficiency and renal insufficiency should be treated as though they were primary diseases, without regard to the acromegalic condition.

The treatment of glycosuria should be cautious, *i.e.*, the true diabetic diet should be assumed with care, if at all. If diabetes is present, the patient might be fed on pancreas, as in acromegaly diabetes seems to be generally, if not always, of pancreatic origin.

The specific treatment of acromegaly undoubtedly must bear some relation to the secretion of the pituitary gland. I believe that, like exophthalmic goitre, we may have an increased pituitary secretion, or a diminished secretion, or a perverted secretion. In some cases, or at certain stages, of exophthalmic goitre we have a set of symptoms, such as great nervousness and cerebral irritation, exophthalmos, palpitation, and loss of weight. In these cases or at these times thyroid feeding will aggravate every symptom. In other cases we have dulling of the intellect, mild exophthalmos, cardiac weakness without much palpitation, muscular debility, and a putting on of weight—in other words, some of the symptoms of myxœdema, due to a diminished thyroid secretion, all of which symptoms ameliorate with thyroid feeding.

During the stage of almost imperceptible, gradual, and perhaps symmetrical growth of the bones, pituitary feeding would probably be of no benefit, and might even aggravate or precipitate unpleasant symptoms, such as headache. But when a case of acromegaly comes into our hands for treatment the hypophysis disease has progressed far enough to give nervous symptoms and selective enlargements so typical of the disease. At this time we are probably having a diminished amount of normal secretion or a wholly or partially perverted secretion from the hypophysis, causing terrible headaches, irregular nerve and muscle pains, vasomotor disturbances, muscular weakness, cardiac weakness, and perhaps severe cerebral irritation. For this condition and at this time pituitary substance will, I believe, often, if not always, be found of marked benefit.

In a case of acromegaly that I am now treating I have obtained good results from pituitary tablets, the dose varying from six to twelve grains a day. In this case the headache, which had been continuous for two years, is now but rarely present. While under the treatment the appetite improves, the muscular weakness disappears, the nervous restlessness is gone, and the patient is able to do her usual work, which she was not able to do before the use of the pituitary substance. Also, the hypertrophy of the soft parts of the face, hands, and feet greatly diminishes. On stopping the treatment, the headaches and muscular weakness again develop, and the face and hands very noticeably again increase in size.

It is probable that in the cases in which the thyroid gland is pathologically so changed that it cannot furnish its normal secretion, as denoted by mild myxœdematous symptoms, the feeding of thyroid extract might be of some benefit.

I do not believe that any treatment other than the above, and general tonic and hygienic treatment, is of any avail in this disease. *Oliver T. Osborne.*

ACTINOMYCOSIS.—This disease is a combination of abscess formation and new growth of connective tissue. In most cases the disease has the character of a subacute or chronic suppurative process, but in some cases the new growth of connective tissue may be so marked a feature of the process that it may present the character of a tumor or neoplasm. The disease affects man and certain domestic animals, particularly cattle, in which it is probably best known. It has a wide geographical distribution.

In cattle it most commonly affects the jaw bones, where it may take origin in the medulla or the periosteum, and may lead to the tumor-like conditions which have been long known as medullary sarcoma or osteosarcoma of the jaw, or as "lump jaw," etc. The external soft parts about the jaws and face, the tongue, the peripharyngeal tissue, the stomach, the skin, and the subcutaneous tissues in various places, may also be the seat of the disease. Anatomically, the lesions consist in general of an overgrowth of granulation and connective tissues, throughout which are distributed, more or less numerously, small, yellowish, soft suppurative areas or abscesses. If the seat of the lesions be the jaw, there is usually more or less new growth of bone as well.

In swine the mammæ, the peripharyngeal tissues, the vertebræ, and the spleen have been observed to be the seat of the disease. In horses the disease may occur in the spermatic cord after castration, as well as in the jaw bones and in the bones of the extremities. A few cases of the disease have been observed in dogs.

In man the disease is probably more common than is generally supposed. It most frequently affects the tissues in and about the oral cavity, the pharynx, and the neck. It also frequently affects the lungs, the bones of the thorax, and the intestinal tract. Almost any organ or part of the body may become the seat of the disease. Anatomically, the disease in man is essentially a destructive suppurative process accompanied by a new growth of connective tissue which in general is not as abundantly developed as in the disease in cattle, so that in man the tumor-like lesions are less frequent.

The disease is due to the action of a vegetable parasite

upon tissues which are suitably susceptible. This parasite is an organism closely allied to the bacteria, but belonging to a higher class. It occurs in the lesions, and in the discharges from them, as small aggregations or

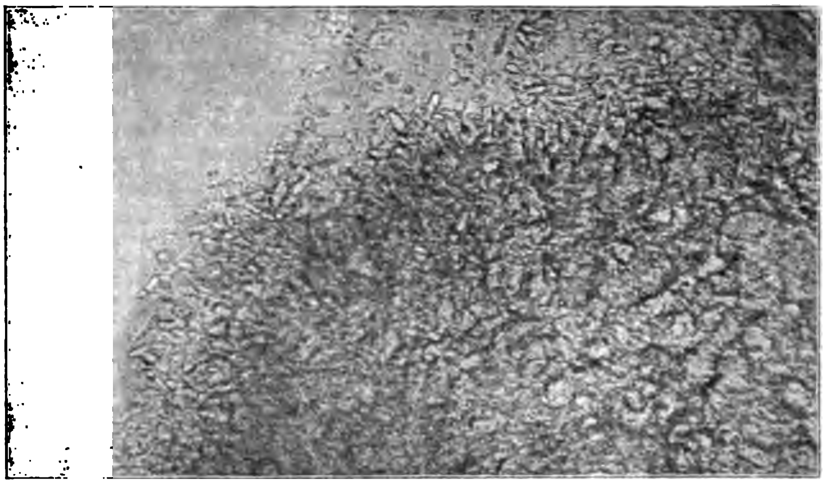

FIG. 28.—Portion of the Margin of an Actinomycotic Granule, crushed under a cover glass, as it appeared under a moderately high magnifying power. Various forms and appearances of the "clubs" are shown.

colonies, of variable size, which in most cases are visible to the naked eye as grayish or yellowish granules or lobulated bodies, less than 1 mm. in diameter. The presence of the peculiar granules in the lesion or in the pus is characteristic and diagnostic of the disease. As a rule they are soft, and when placed on a slide and covered with a cover glass, they are flattened or crushed by the weight of the latter. In some instances, especially in cases in cattle, they may be more or less calcified. Under a low magnifying power a granule crushed beneath a cover glass will appear as an aggregation of lobulated hyaline masses, with rounded, finely serrated borders which may have a slightly brownish tint. In some instances a fine radial striation may be made out at the margins. As a rule masses of pus cells will be found surrounding the hyaline masses and making up a portion of the bulk of the granules. Under a higher magnifying power the hyaline material in places will have the appearances of being made up of a dense feltwork of delicate filaments having the diameter of bacilli of moderate size and closely packed together. At the margins these filaments usually have a radial arrangement, and some of them project beyond the limits of the hyaline mass. In the case of some granules, the margin of the hyaline mass may be formed of a row of closely set, elongated, finger-shaped, or club shaped, or bulb-shaped bodies, composed of a hyaline substance and arranged radially (Figs. 28 and 29). These bodies constitute the so-called "clubs" or "rays" on account of which the name "ray fungus" has been applied to the parasite. They are of variable size and width, often being three or four times the width of the filaments. In stained preparations a stained filament may often be seen in the median portions of the "clubs" or "rays," which for this and other reasons are regarded as modifications of the marginal filaments (Fig. 29). In fact, it seems very probable that these bodies are nothing more than the results of degeneration of the marginal filaments, as has been pointed out by Boström ("Beiträge zur path. Anat. u. allgem. Path.," Ziegler, bd. ix., 1890). The "clubs" are much more frequently found in the granules from lesions in animals than in those from man. If one of the granules be broken up on a cover glass and suitably stained there will be seen on microscopical examination, besides long filaments which branch, short rod-like or bacillus-like or coccus-like forms (Fig. 30). At the present time it is considered that the bacillus- and coccus-like forms are the result of degeneration and of breaking up of the filaments. Some writers seem to think that the presence of the "clubs" or "rays" is a constant and necessary feature of the granules of genuine actinomycosis, and so they call those cases pseudo actinomycosis in which granules are found which have little more to distinguish them from true actinomycosis than the absence of these bodies. In view of the fact that in one and the same case granules, both with and without "clubs," may be found, it seems probable that the so called pseudo-actinomycosis is really not distinct from the true disease.

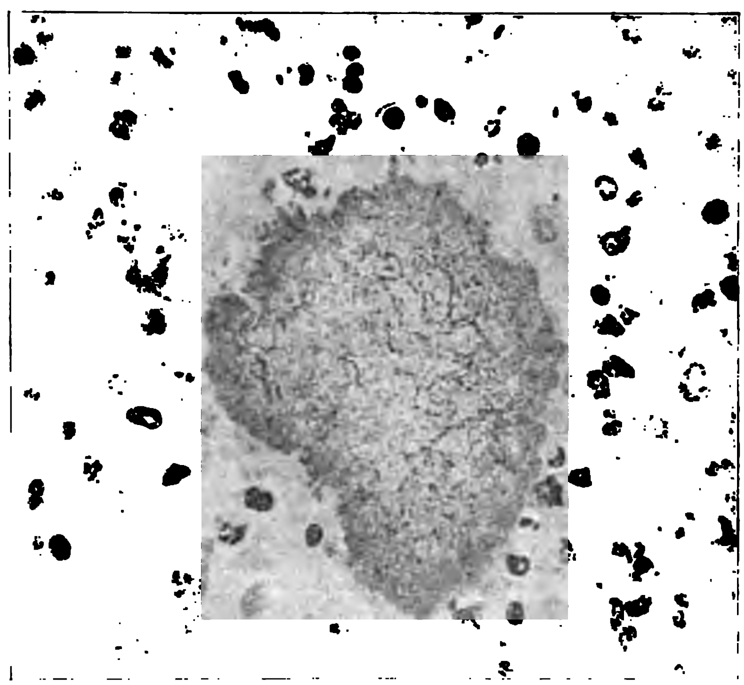

FIG. 29. A Granule or Colony of Actinomyces, in a section about two micromillimetres thick, showing the "clubs" with central filaments at the margin. The general structure of the colony is shown also. From an abscess in the heart in a human case. × 750.

Microscopically, the lesions consist of larger or smaller abscesses, each containing one or two of the granules or colonies, and bounded by connective tissue, in all grades of development (Fig. 31). In the latter, giant cells may

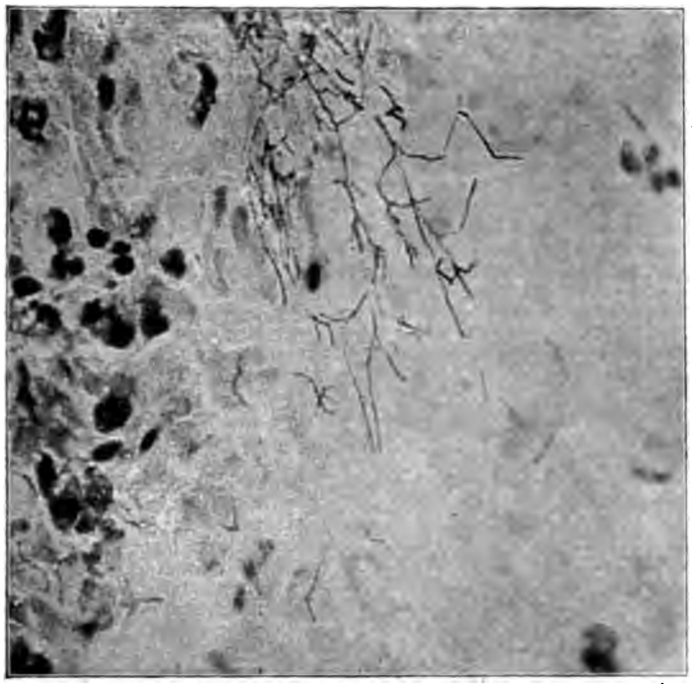

FIG. 30.—A Cover-Glass Preparation Made from a Granule. Some rods and branching filaments in association with pus cells are shown. × 1,000.

name that has clung to it ever since. The disease in man was first recognized and identified as due to the same cause as that found in the disease in cattle by Ponfick a short time after Bollinger's publication. The granules, however, had been seen in a suppurative process in the neighborhood of the vertebræ in man by Langenbeck in 1845, and had been described and figured by Lebert in his "Atlas of Pathological Anatomy," published in 1856.

Many untrustworthy observations have been published concerning the cultural peculiarities of "Actinomyces bovis." It is commonly stated in text-books that culture methods have shown that various pathogenic species of this parasite are known, but the writer considers that the observations upon which these statements are based are open to serious question.

According to Wolff and Israel (*Archiv f. path. Anat.*, Virchow, 1891, Bd. 126), the organism grows on agar practically only in the absence of oxygen. Cultures made by breaking up the granules and spreading the fragments over the surface of the agar begin to show the growth of colonies after about three days. Some days later the colonies may have attained the diameter of 2 or 3 mm. They are grayish white in color, rounded in outline, with wavy margins in some instances, and often have an elevated nodule in the centre.

In bouillon, growth may be obtained without the exclusion of oxygen. Granules planted in this medium become larger in size and break up into small, white, irregular masses in the course of a few days. The growth then appears as a sediment at the bottom of the culture tube, composed of opaque, whitish, irregular granules, usually less than

be present. A granule in a section stained by Gram's method appears as a mass of filaments embedded in a hyaline material and showing at the margin more or less radially arranged filaments, or the "clubs" or "rays" previously described (Figs. 29 and 32). The hyaline material seems to be composed in many instances of non-staining degenerated filaments. In other instances the nature of this hyaline material is not clear, but it is very probably the result of degenerative processes in the colony. It is not uncommon to see bacillus-like fragments of the organism in or among the pus cells surrounding the colony.

The pathological significance of the granules in the lesions of the disease was first clearly shown by Bollinger in 1877, although their presence had been noted previously by several observers whose work was incomplete and did not receive general recognition. Bollinger regarded the granules as growths of a fungus and as the essential cause of the disease. Harz, a botanist, confirmed Bollinger's ideas of their fungous nature and called the organism "actinomyces bovis," a

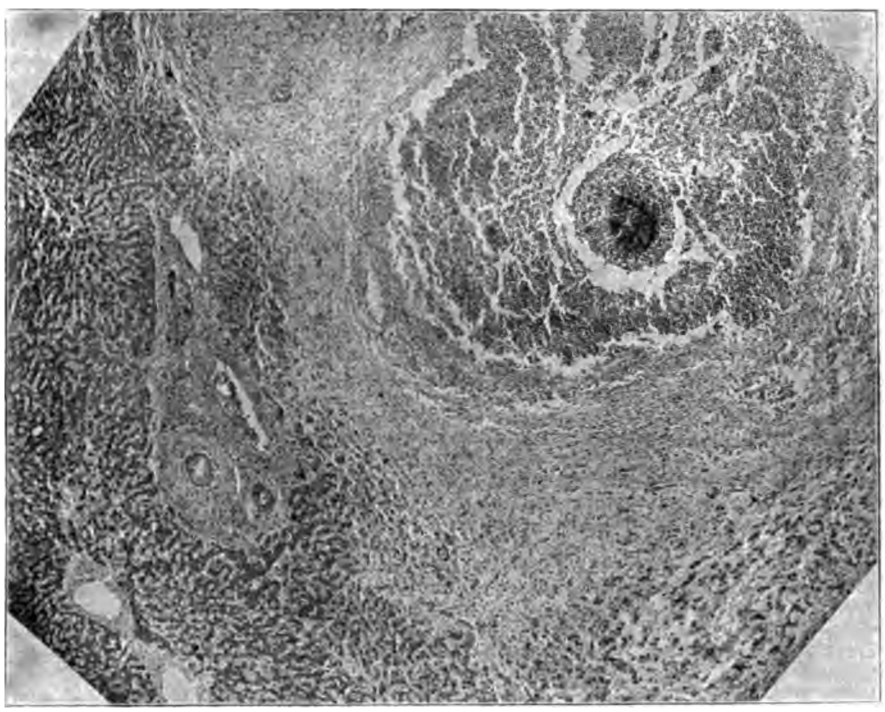

FIG. 31.—Section of a Portion of an Actinomycotic Lesion in the Liver of the Same Case as That Mentioned in Fig. 29. The abscess, containing a "colony" or "granule," and the surrounding connective-tissue growth extending into the liver substance, are shown. The "colony" appears as a rounded, dark mass in the right upper quadrant of the figure. Low magnifying power.

1 mm. in diameter. The granules are often conglomerated into irregular masses. The bouillon is never clouded if the growth is not contaminated.

Microscopical examination of the growth in the culture shows longer and shorter rods and threads, the last mentioned sometimes branching. The organism stains irregularly, and often shows rounded or club-shaped swelling or other irregularities in shape, especially at its extremities. It does not altogether preserve its filamentous character in the cover-glass preparations from the cultures. This is probably due to the fact that the filaments are broken up in the manipulation. An additional peculiarity of this organism is the presence of deeply staining rounded or oval bodies in the rods and threads. These are of about the same diameter as the rod, and are frequently distributed along the length of the rod or filament at variable intervals. Their nature and function are not understood.

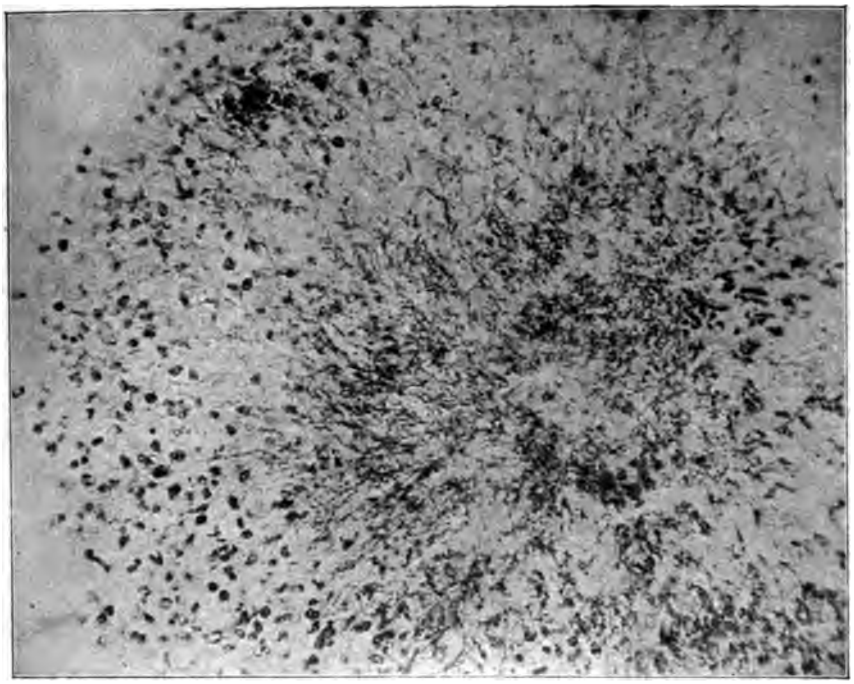

FIG. 32.—A Colony of Actinomyces in a Section of the Same Lesion as in Fig. 29. This is a colony composed of filaments and hyaline substance. There are no "clubs." × 500.

Animal inoculations with actinomyces at the hands of various investigators have not led to conclusive results. Max Wolff and James Israel (*loc. cit.*) in 1891 published the most interesting work that has ever been done on this subject, but their results lack confirmation.

The exact position of the organism in the botanical world is still a matter of discussion, as is also the name of the group of micro-organisms to which it belongs. On account of its branching it is to be regarded as belonging to a more highly developed group than the bacteria, while it is not so highly developed as to be classed with the moulds or hyphomycetes. The tendency at the present time is to call it and similar branching organisms "streptothrices." Of such organisms a small number have been more or less satisfactorily described, some of which have been met with in inflammatory processes. The precise relationship of these to actinomyces bovis is not very clear at the present time.

The most frequent seat of primary actinomycosis in man is the tissues about the buccal cavity and the neck. Primary actinomycosis of these parts forms more than half of all the recorded cases. Next in frequency is primary actinomycosis of the digestive tract and of the lungs. Primary actinomycosis of the outer skin, exclusive of the skin of the face and neck, is less frequent. Ruhräh (*Annals of Surgery*, October, November, December, 1899, vol. xxx., Nos. 4, 5, 6), who has collected all the reported cases that he could find in the literature, gives the following figures: Total number of cases, 1,094, including certain cases probably counted more than once. In these the disease affected the head and neck in 56 per cent., the digestive tract in 20 per cent., the lungs in 15 per cent., and the skin in 2 per cent; 6 per cent. are classified as doubtful. Various cases have also been recorded of actinomycosis of various organs, including the brain, without any demonstrable primary lesion in the situations above mentioned.

The infecting organism is probably frequently carried into the tissues along with foreign bodies, especially such as occur in food material in the case of cattle. The not infrequent finding of such foreign bodies in or near the lesions of the disease, and the observations of the increase of the disease in herds of cattle when a change has been made in their food, as also the very frequent localization in the neighborhood of the mouth, pharynx, etc., support this idea. No one, however, has satisfactorily demonstrated the parasite outside of the lesions, and we know nothing definite concerning its habitat in the outer world. There is evidence that the infection may be transmitted from animals to man or from one individual to another.

Actinomycosis in man is distinguished from the disease in cattle not only by a less extensive new formation of connective tissue, but also by its greater tendency to the formation of fistulæ and sinuses, by which the disease may extend widely from one organ to another. Such sinuses may extend from the tissues about the mouth or pharyngeal cavities deeply into the thorax and along the spinal column (prevertebral phlegmon). In actinomycosis of the lungs fistulæ may perforate the chest wall or go through the diaphragm into the abdominal cavity. In actinomycosis of the intestines fistulæ may form which usually perforate the anterior abdominal wall; they may, however, extend through the lumbar region or into the rectum or bladder. The disease may also extend metastatically through invasion of the blood stream by the organism, and in this way various organs at a distance, such as the heart, brain, kidneys, etc., may become the seat of the disease. Only rarely does it spread by the way of the lymphatics. Secondary infections with pyogenetic cocci may occur.

The clinical course and prognosis of the disease depend upon its extent and localization, and upon the occurrence of secondary infections with the pyogenic cocci. The last mentioned is an unfavorable complication. In extensive involvement of internal organs there may be fever and marked disturbance of nutrition. In localizations about the buccal cavity and neck there is good evidence that many of these cases will heal by the simplest surgical treatment or even spontaneously. Probably many such cases go unrecognized. The bones of the jaw are rarely affected in man. The occurrence, in the soft parts

of the neck or cheek near the jaw, of hard swellings which have arisen painlessly and present a fluctuating or suppurating focus, should excite suspicion of actinomycosis.

Actinomycosis of the lungs in general resembles chronic pulmonary tuberculosis. The affection may last for months or years. It is characterized by cough, by much sputum, which is often fetid or bloody, and by marked pains in the breast and back. There are also irregular fever and progressive emaciation. Fistulæ perforating the chest wall and involving the sternum or ribs are not infrequent. In this the disease differs radically from tuberculosis of the lungs. The prognosis is generally bad. Remissions with appearances of healing occur. The process may be localized in any part of the lungs. It usually appears as small abscesses or broncho-pneumonic patches, from which cavities may be formed accompanied by new growth of connective tissue.

Actinomycosis of the intestines is characterized by extensive induration due to a marked development of peritoneal adhesions and to the extension of the process to the abdominal wall and neighboring organs. As before mentioned, the tendency to the formation of the fistulæ is marked. Metastatic involvement of the liver is not unusual. The prognosis must be regarded as unfavorable in general.

Actinomycosis of the skin, according to Leser (*Archiv f. klin. Chir.*, 1899, xxxix.), may appear as a circumscribed ulcerated lesion or as a nodular formation with central cicatrizations. The subcutaneous tissue may also be affected and a chronic phlegmonous condition be produced.

One of the forms of the disease known as "Madura foot" is very probably actinomycosis of the part. This is the so-called "white" or "ochroid" variety, in which the characteristic granules in the lesions are of this color. The "black" or "melanoid" variety of "Madura foot" is due to an altogether different vegetable parasite, which is a hyphomycete (Wright: Transactions of the Association of American Physicians, 1898, *Journal of Experimental Medicine*, vol. iii., 1898).

The diagnosis of actinomycosis is made by finding the characteristic granules or colonies of the organism in the lesions or in the discharges from the same. These in some instances may be so obscure as to escape observation with the naked eye. Microscopic examination is necessary to distinguish the colonies or granules from small pieces of necrotic tissue and masses of pus cells. The pus or suspected material should be spread on a piece of glass. In this way the granules will be more easily seen. In actinomycosis of the lungs the organism may be found in the sputa and in the discharges from fistulæ in the wall of the thorax. In the sputum the parasite is to be distinguished from the common leptothrix of the mouth by the fact that the filaments of the latter are larger, straighter, and thicker and do not branch as do the filaments of actinomycosis. The leptothrix filaments are also frequently adherent to epithelial cells.

The treatment of actinomycosis should be operative if the extent of the disease admits of it.

In internal treatment good results are said to have been obtained from the use of potassium iodide.

The photographs which accompany this article were made by Mr. L. S. Brown and the writer, in the Clinico-Pathological Laboratory of the Massachusetts General Hospital.

James H. Wright.

ACTIVE CONSTITUENTS OF PLANTS, Classification of.—If this term were strictly interpreted, we should omit from consideration all but those constituents which produce positive physiological effects, other than nutritive, upon the animal system. As this treatment would exclude some substances having important medical and pharmaceutical relations, especially the latter, it is deemed better to consider briefly all plant constituents which affect the properties or uses of drugs or medicines.

Of the nutrients proper, the albuminoids may be dismissed as of neither medicinal nor pharmaceutical importance in the department of materia medica. The sugars, inulin, starch, and cellulose, as well as the more important plant acids, are considered in their respective alphabetical order. The other principles of interest to us may be conveniently divided into the inorganic and the organic. The inorganics from this source are not treated as of importance in the modern materia medica. The vegetable compounds of iron, being readily assimilated, are probably worthy of much more study and rational employment than has been the case heretofore. Sea weeds have long been a well-known source of iodine, and some vegetable drugs apparently owe their properties largely to this element. For the rest, the value of the inorganics in drugs depends chiefly upon the presence, especially in such fruits as prunes and tamarinds, of the well-known laxative salts, the properties of which do not differ from those of inorganic origin. It is possible to obtain important cutaneous stimulant effects from the use of many vegetable substances rich in needles of calcium oxalate, although the fact has never been duly appreciated.

The organic constituents which here require attention are the vegetable acids, gums, fixed oils, resins, volatile oils, amaroids, glucosides, alkaloids, and enzymes, together with such mixtures as oleoresins, gum-resins, and balsams.

Vegetable Acids.—The number of vegetable acids which have been extracted from plants is very great, though only a few are found widely distributed among different plants. In the plant they serve a variety of useful purposes. Some of them, at least, act as reserve foods, being manufactured during darkness and consumed in the light, while the reverse is true of starch. They combine with organic and inorganic bases, which are thus rendered soluble and transportable. They render many fruits more palatable, thus influencing dissemination, and, on the other hand and in other cases, by their irritating or antiseptic properties they protect the plant against its enemies. Those which are of a resinous nature are thus particularly useful in preventing fermentation and decay (see Resins). Another class form an essential element in the composition of fats and are known as fatty acids (see Fixed Oils). Some of the vegetable acids, as tannic, citric, benzoic, and hydrocyanic, are of direct use as medicinal agents, while others are of pharmaceutical interest, as influencing the extraction of the associated substances. It has been claimed in numerous instances that a basic organic substance is more efficient when administered in combination with its natural acid. Many of the natural compounds of these acids are with the inorganic constituents, and it is these salts which chiefly render some fruits and vegetables laxative. The antiseptic properties which render many acids of value to the plant are made to render a similar service to man.

The acid properties of the vegetable acids are much weaker than those of the inorganic acids, so that they yield up their bases to the latter. They are also less corrosive and irritating than the latter, and they cannot perform the same service in digestion. Taken continuously or in excess, they can impair digestion or cause gastritis, and they are supposed to favor a rheumatic diathesis. Their salts are commonly more soluble than those of the inorganic acids. Their incompatibilities are in general the same as those of the latter.

Gums are supposed to exist as waste substances in the plant. They usually form in successive layers upon the inside of the cell wall—the process known to botanists as "mucilaginous degeneration." While these statements are true of those gums which are collected as such for medical and pharmaceutical uses, another class, occurring in such drugs as althæa, apparently act as reserve foods. These are of interest as affecting pharmaceutically the preparations of drugs. The gums are insipid, insoluble in alcohol or ether, but soluble in water to form a mucilage or an adhesive jelly. They differ in their precipitation tests, but are mostly precipitated by lead acetate and by alcohol. Their presence in an alkaloidal solution will very often prevent the precipitation of the latter by tannin and by weak solutions of metallic salts. Chemically, the gums are compounds of special acids with

potassium, calcium, and magnesium. Medicinally the gums are inert, but they serve to form a protective covering in many cases, thus guarding against irritation, as in corrosive poisoning. When used externally for this purpose, some antiseptic substance should be added. Mucilaginous substances are highly prized in the making of poultices, because of their marked power to retain heat and moisture. Here, also, it is desirable to add an antiseptic.

Pectose, the mucilage-like or gelatinous constituent of such fruits as apples and pears, and of such vegetables as turnips and beets, acts pharmaceutically like mucilage, being soluble in aqueous extracts, but precipitated upon the addition of alcohol.

The gelatinous principle of sea weeds shares the properties of gum and pectose, and exists in very large percentage.

Fixed oils, or *fats*, as those oils are called which are solid at ordinary temperatures, are compounds of special acids, known as fatty acids, with glycerin. From the names of these compounds those of the acids are derived, as oleic acid from "olein," stearic acid from "stearin," palmitic acid from "palmitin." Many fats are mixtures of such compounds. In the plant, fats are stored in parenchymatic tissue in the cell cavity. As they are reserve foods, of special use in the developing embryo, we find them specially characteristic of seeds, stored in both endosperm and embryo. They have a characteristically smooth feeling to the touch, are not volatile or inflammable, but combustible, insoluble in water, rarely soluble in alcohol, and then but partly so (see *Castor* and *Croton Oils*), but are soluble in volatile oils, ether, and chloroform. Heated with or kept mixed with alkalies, they are decomposed into their glycerin, which is left free, and their acid, which unites with the alkali to form soap, the process being known as "saponification." On exposure to the atmosphere, they undergo a peculiar decomposition known as rancidity, giving them a very disagreeable odor and taste. Physiologically, they are important nutrients, of exceptional value because of their ready absorbability through the skin, especially when rubbed upon it. They are not dialyzable, but by the aid of an albuminous substance and of gum they are resolved into an extremely finely divided state of suspension known as an "emulsion," and, more or less of this change taking place in the intestine, they can then become absorbed. They act as protectives, and, by their lubricating and softening power, as laxatives, whether taken internally or per rectum. It has been suggested that if taken in large quantities, the glycerin set free by their saponification in the duodenum acts as a laxative also.

They readily dissolve a great number of substances, and become thus of the greatest use pharmaceutically, as vehicles. This use is the more important because of their great absorbability, which favors the absorption of many dissolved medicinal substances used externally and internally. This property has to be considered in poisoning, as some poisonous substances not naturally absorbable from the intestine may be so under their influence. Fats are naturally destructive to insect life, apparently by clogging up their breathing apparatus. They therefore exert an important action as parasiticides and increase the activity of other agents of this class. For similar reasons, they are efficacious in destroying ascarides. The medicinal effect proper of fixed oils is very slight, if we except a few like castor and croton oils, which are apparently complex substances and contain an irritating element. The same is probably true of toxicodendrol, the poisonous fat of poison ivy and its relatives.

Resins.—These are in some respects like the fats, in others like the volatile oils. They are solid, non-volatile and non-inflammable, but fusible and combustible. They are insoluble in water, but most readily soluble in volatile oils; frequently also in alcohol, fixed oils, ether, and chloroform. They are acid in nature and are saponified by alkalies, giving us a series of resin soaps. Nitric acid converts them into a peculiar substance resembling tannin. They are apparently, at least for the most part, waste substances in the plant, which transports them through its tissues dissolved in volatile oils; as *liquid oleoresins*, in which form they are stored in special lacunæ, ducts, or tubes. They are of use to the plant by rendering its food storage parts antiseptic and disagreeable, or even dangerous, to animals eating them. Pharmaceutically, the resins are very troublesome, as they are dissolved in the alcohol in the extraction of many drugs, and are then most easily precipitated upon the addition of water, and often of acid substances. As to their medicinal properties and uses, the resins, by warming, become adhesive and have numerous and important uses depending upon this property. Those which are little irritating can be used as protectives, upon the evaporation of their solutions painted upon the surface. They are more or less antiseptic; less so than volatile oils. They are usually more or less irritant, many being thus available as counter-irritants. One class of them exhibit this irritating property especially in the intestine, and become purgative, some very powerfully so. Among these may be mentioned those of jalap, scammony, podophyllum, leptandra, iris, and euonymus. Preparations of such drugs should be thoroughly subdivided through an excipient, so that no large particle shall lodge in a pocket of intestine and produce undue irritation.

Gum-resins are merely mixtures of gum with resin, which adapts them very well to being used in the form of emulsions. Not only do the relative percentages of gum and resin vary widely in different gum-resins, but the percentage is quite variable in different lots of the same. The activity is, of course, proportional to the percentage of resin. Important gum-resins are myrrh, asafœtida, ammoniac, elemi, galbanum, and gamboge. They occur also in many drugs, such as sumbul, angelica, parsley, and lovage. Volatile oil is a very common constituent of gum-resins.

Volatile Oils.—For the sake of long custom and convenience, these are treated as a class of active constituents, although the idea is not a scientific one. They are in reality mixtures which are very indefinite in kind, as well as in degree. The name may without impropriety be extended to all volatile and aromatic constituents of plants. They consist mostly of one or more oxygenated compounds mixed with one or more hydrocarbons, usually terpenes. Of these, the former is commonly the active one. Since volatile oils are rather irregular in the relative amounts of the active and the inactive portions, and also highly subject to adulteration, which is very difficult of detection, the use of the active constituents, the purity of which is readily ascertained, is much preferable to that of the oil. Doubtless such use will extend as these facts become more generally appreciated, and this result will be hastened by a more common custom of regarding and speaking of these oils as indefinite and irregular mixtures, a custom which is carefully followed in this work. Their chief use to the plant is perhaps as solvents of other constituents. Their nutritive relations are not well known, and if they were, they could not be easily defined, owing to their variable chemical nature. Their fragrant properties are undoubtedly of value in indirect ways, such as attracting insects. Their antiseptic properties and the obnoxious character of many of them to some animals undoubtedly serve a protective purpose. They may be found in any part of the plant, perhaps most frequently in the seed. They may often be seen in the leaf, in the form of pellucid dots, when viewed against the light. Owing to their volatile nature, drugs which depend upon their presence are very liable to deteriorate on being kept, and unusual care has to be exercised in their preparation and preservation. On this account they are usually dried in the shade.

These substances leave no greasy stain on paper. They are light, volatile, aromatic, and inflammable. They dissolve in water sufficiently to render the latter aromatic and somewhat medicinal. They are readily soluble in alcohol, fixed oils, and glycerin, and act as solvents of resins, fats, and many medicinal substances. Aside from their medicinal properties, they have a wide use within

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as well as outside the boundaries of pharmacy, in odorizing and flavoring. In their physiological and medicinal properties, volatile oils agree in some characters and vary greatly in others, so that they fall naturally into different therapeutical classes. Their local stimulant properties are very general. This makes them counter-irritant; some of them, like oil of turpentine, very powerfully so, especially when confined under an air-tight covering. Others which are strongly counter-irritant are those of mustard, amber, erigeron, cinnamon, cloves, and camphor. The irritating effect of some volatile oils is followed by a local anæsthesia, occasionally quite strong, as in the case of menthol and oil of cloves. In line with their counter-irritant action may be considered their stomachic and carminative properties, which are perhaps more general than any others. Here again certain oils, especially those of the families Umbelliferæ (anise, fennel, caraway, etc.) and Labiatæ (mint, thyme, pennyroyal, etc.), excel others. As to their gastric effects, it is to be noted that their presence with the digesting food mass tends to inhibit the process. This action also is greater in the case of certain oils, and is said to be quite wanting in that of oil of peppermint, which is thus an exceptionally valuable carminative. Aside from their intestinal effects in stimulating secretion and peristalsis, they exert a strong action in stimulating the sympathetic nerves, thus overcoming the excessive relaxation upon which various forms of serous diarrhœa depend in whole or in part. This action effects a final result similar to that of the true astringents, and makes a combination of volatile oils and astringents highly effective. Their carminative properties render them of great use in combining with griping purgatives. Their antiseptic properties are quite general and strong, though they vary greatly in degree in the different oils. They act not only as direct germicides, but they stimulate the cells themselves in their fight against the foreign organisms. In general, the oils of the family Myrtaceæ and many of those of the Lauraceæ are thus antiseptic, as are those of birch, wintergreen, sandal, copaiba, and thyme. Oil of cinnamon is probably the most powerfully antiseptic of any, eucalyptol, if pure, perhaps standing next. Volatile oils agree in their strongly diffusive properties, on account of which their systemic effects come on quickly. If the vapor is confined, they are quickly absorbed, even through the skin, as they are by inhalation. They then become systemic stimulants, though overdoses may act as depressing poisons. This stimulation makes them antispasmodic in many cases. Elimination begins as promptly as absorption, and their local effects are again seen at the point of excretion. They vary in their selection of the channel of excretion. Some, like eucalyptus, copaiba, and cubeba, have a tendency toward the respiratory mucous membrane and become important stimulating and antiseptic expectorants. Others, like sandal, copaiba, cubeba, birch, wintergreen, turpentine, juniper, savin, tansy, and buchu, have an affinity for the kidney, and become stimulating (to irritating) and antiseptic diuretics, some important antiblennorrhagics. A few, like oil of chenopodium, are powerfully anthelmintic. Those especially adapted to perfuming and flavoring may be named as orange, lemon, bergamot, rose, bay, bitter almond, citronella, lavender, nutmeg, and cinnamon.

Oleoresins, being resins dissolved in volatile oils, naturally combine their properties. They very often, however, contain a third substance in addition, and this may give to them specific properties distinct from those of either the oil or the resin, and in some cases exceedingly powerful. The most important oleoresins in use are those of the male fern, capsicum, ginger, copaiba, black pepper, cubeb, turpentine, and hops. Other important oleoresins contained in drugs but not commonly isolated for use are those of calamus, iris, inula, prickly ash, mezereum, and stillingia.

Balsams are liquid or solid oleoresins depending in part for their properties upon the contained benzoic or cinnamic acid, or both. Their properties are readily deduced from this composition. The principal ones are benzoin, dragons'-blood, tolu, and peru. Copaiba, though commonly so called, is in no sense a balsam.

Amaroids (their Latin names ending in "*inum*," their English in "*in*").—This term has been proposed for those bitter extractives of plants which, having a definite chemical composition, do not belong to any of the recognized classes of proximate principles. While not highly scientific, the term is often very convenient.

Glucosides (their Latin names ending in "*inum*," their English in "*in*").—These are compounds of glucose with some other substance, the latter class covering a wide range and occasionally containing nitrogen. They are especially numerous in the Liliaceæ, the Apocynaceæ, and some other families, but are very widely distributed elsewhere. They act as reserve foods to the plant, and are therefore more abundant in those parts which act as storage reservoirs, and at the close of the growing period. The bodies associated with the glucose are very frequently poisonous or obnoxious, subserving thus a protective function, while the glucoside in this way also acts as a protective of other parts or constituents. Owing to the readiness with which they are decomposed (in the plant by special enzymes), their nutritious portion is very readily available and at once assimilable. For the same reason they constitute very unstable medicinal agents and, like drugs containing them, require to be treated with very great care in pharmaceutical operations. They are mostly soluble in both water and alcohol. Some, like amygdalin, are inactive until such decomposition occurs, while others may be thus rendered inactive. Such decomposition is effected by the action of dilute acids, especially if heated, by hot water, and by the prolonged action of alkalies. They are mostly precipitated by tannin and lead acetate, and very frequently by mercuric chloride. They are usually very energetic physiological agents, but their actions are too diverse for generalization. It may be said, however, that they are as a class more disposed to act upon the circulation than in any other one direction. Several of the glucosides are widely distributed among different plants, and, exhibiting variations among themselves, may be regarded as forming sub-classes. Tannin or tannic acid (elsewhere considered) is technically a glucoside, but differs so much from the others that it is difficult to regard it as such. The *saponin* group (see *Saponin*) have also distinct and important properties. The chief interest in glucosides as a group centres in their incompatibilities, as indicated above. The principal glucosidal drugs are as follows:

Bitter almonds, Peach seeds, Wild cherry, Cherry laurel, Peach, plum, and cherry leaves, etc.,	Amygdalin.
Buckthorn, cascara sagrada, and other species of Rhamnus, Aloes, Rhubarb, Senna,	Emodin or relatives.
Apocynum—apocynin and apocynein.	
Convallaria—convallamarin and convallarin.	
Digitalis—digitalin and others.	
Dulcamara—dulcamarin.	
Phytolacca—phytolaccin.	
Piper—piperin.	
Soap bark, Soap root, Euonymus, Senega, Caulophyllum and others,	Saponin or a similar body.
Squill—scillin and others.	
Black mustard—sinigrin.	
White mustard—sinalbin.	
Strophanthus—strophanthin and strophanthidin.	

Alkaloids (their English names ending in *ine*, their Latin in *ina*, although it is now proposed to abolish this most convenient distinction and to spell them with a final *in*, a practice actually now in use to a great extent in Germany).—These are nitrogenized organic bases, occurring in plants (also in animals) usually, if not always, as waste products, and in combination with acids. Although commonly waste products from a nutritive standpoint, they perform the most useful purposes in the plant economy. Usually poisonous and intensely bitter, they often serve to

protect those parts of the plant which are used for food storage from consumption by animals. They may occur in any part of the plant, but are most often found in the seeds, leaves, and bark of both stem and root. They are characteristically common in some families, like the Rubiaceæ, while from others, like the Compositæ, the largest of all families, they are nearly or quite absent. Alkaloids are usually crystallizable. Many were formerly known only in a liquid or amorphous state, but many of these, when thoroughly purified, have since been found crystallizable. Those which are not so, yet usually yield salts which are. Some alkaloids are volatile. Many alkaloids, while acting as proximate principles themselves, readily separate, either in the plant by natural processes or under laboratory treatment, into other alkaloids and some associated substance, so that series of them are formed. These are necessarily of unstable chemical composition. In some cases, an alkaloid will result from the decomposition of a glucoside, as solanidine from solanin. Alkaloids differ greatly in solubility, but the strong tendency is toward solubility in alcohol and insolubility in water, while of their salts the reverse is true. A few which vary markedly from this rule are enumerated below. These bodies show their basic nature by turning red litmus paper blue, but more especially by uniting with acids to form salts. They do this without displacing the hydrogen of the acid, as metals do. They vary greatly in the intensity of this affinity for acids, some, like caffeine, being very feebly basic. In some cases we are even uncertain whether they can properly be classed as alkaloids. Alkaloids are as a class probably the most active physiological constituents of plants. Their actions are so dissimilar that they cannot be at all generalized, except to say that by their almost invariably bitter taste they act, in the absence of other antagonistic properties, as bitter stomachics and tonics. In many cases two alkaloids, the one a derivative of the other, occur in the same plant, with antagonistic properties. Alkaloids converted into *methyl* compounds are thus usually antagonistic to those so yielding them.

It is of the utmost importance that the prescriber should keep in mind the incompatibilities of alkaloids. Some of these incompatibilities are innocent, or can even be utilized in important ways. Thus the addition of acids converts alkaloids into salts, which may then be dissolved in water, the physiological properties being usually unaltered. These salts differ greatly in solubility. In most cases acetates are the most soluble, hydrochlorides next, and sulphates the least. In other cases, a physical incompatibility exists, so that the alkaloid is precipitated. Owing to their energetic action such a result is exceedingly dangerous, the first portions of the medicine being ineffective, the last portions poisonous. In this connection it may be stated that all salts which will turn red litmus paper blue will precipitate aqueous or weak alcoholic solutions of alkaloidal salts. Such solutions are almost always precipitated by alkali hydrates, soluble salicylates, benzoates, iodides, and bromides, tannic acid, chlorides of mercury and of gold. The presence of mucilage or hydrated starch will sometimes prevent this precipitation, especially that by tannic acid. In other cases incompatibility involves the destruction of the alkaloid. Oxidizing agents will usually accomplish this result, except when they enter into a saline combination. This fact is utilized in some cases of antidotal treatment, as of morphine by potassium permanganate. Chloral hydrate is incompatible with many alkaloids, forming a soft or liquid mass. The solanaceous alkaloids, of which atropine is the type, as well as aconitine and coniine, are decomposed by alkalies. The strength of many drugs can be readily standardized by determining the average percentage of alkaloid contained.

The principal drugs which depend upon alkaloids for their activity are the following:

Aconite (aconitine).
Aspidosperma (aspidospermine, a mixture of six).
Belladonna (atropine).
Berberis (berberine).
Coffee (caffeine).
Cannabis indica (?).
Chelidonium (chelerythrine and chelidonine).
Cinchona (quinine, cinchonine, and cinchonidine, chiefly).
Coca (cocaine).
Colchicum (colchicine).
Conium (coniine).
Ergot (?).
Gelsemium (gelsemine and gelseminine).
Granatum (pelletierine).
Guarana (caffeine).
Humulus (trimethylamine, partly).
Hydrastis (berberine, hydrastine, and [artificial] hydrastinine).
Hyoscyamus (hyoscyamine and hyoscine).
Ipecac (emetine and cephaeline).
Lobelia (lobeline).
Menispermum (berberine and menispine).
Nux vomica (strychnine and brucine).
Opium (many, the principal being morphine, codeine, narcotine, narceine, and the artificial derivatives apomorphine, apocodeine, and heroine).
Physostigma (physostigmine or eserine).
Pilocarpus (pilocarpine and pilocarpidine).
Piper (piperidine, partly).
Sanguinaria (sanguinarine, chiefly).
Scoparius (sparteine, partly).
Spigelia (spigeline).
Staphisagria (four alkaloids, the properties not well differentiated).
Stramonium (daturine, a mixture).
Tobacco (nicotine).
Veratrum (veratrine, a mixture).

Important alkaloids which are soluble in water are coniine, codeine, caffeine, nicotine, atropine (nearly four grains to the ounce), pelletierine, lobeline (considerably).

Alkaloids which, with their salts, are little soluble in ordinary alkaloidal solvents are strychnine and sparteine.

Enzymes.—These are vegetable ferments, acting like the animal ferments, pepsin, trypsin, etc., in decomposing or digesting nutrients for the use of the plant. There are different classes of them, each acting upon a certain class of nutrients. The diastases acting on starch have become extensively utilized in medicine, but most enzymes have not. One class has for its function the decomposition of glucosides, another the digestion of amaroids, another acts upon certain gums. Unlike pepsin and others of its class, the vegetable enzymes can be extracted in a pure condition and their composition determined. *H. H. Rusby.*

ACUPRESSURE.—A procedure devised by Sir J. Y. Simpson, of Edinburgh, in 1859, for arresting hemorrhage from a vessel by means of pressure made by a needle transfixed through the neighboring tissues. The flow of blood through an artery may be arrested in any one of three ways. The vessel may be simply compressed between the needle and some firm tissue, as a bone or the integument, as represented in Figs. 33 and 34. When the artery lies embedded in a soft tissue, as in a divided muscle, its occlusion may be accomplished by torsion. This is done by introducing the needle on one side of the vessel, and, when it has passed through a portion of the tissue, twisting it around the artery, and fixing its point in the tissue in a direction opposite to that in which it was first entered; or the artery need not be included in the bight of the needle, but the latter may be turned before reaching the vessel, the latter then being compressed by the elastic force of the twisted tissues acting upon the needle. A third method, appli-

FIG. 33.

cable also in cases in which the vessel lies in a yielding tissue, consists in pressure between the needle and a slip-knot. The needle is passed beneath the artery, and a loop of fine wire is slipped over its point, the ends of the loop passing over the artery, and being fastened by two or three turns over the shaft of the needle (see Fig. 35). In the case of small vessels, the needles may be withdrawn at the expiration of twenty-four hours; but when large arterial trunks are occluded, the pressure should be maintained for forty-eight hours at least.

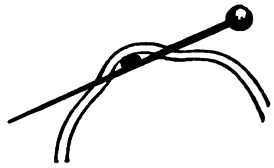

FIG. 34.

The advantages claimed for this method are: the ease and rapidity with which the needles may be applied, no delay being caused in the operation; the absence of danger from suppuration of the ends of the divided vessels; and non-interference with rapid closure of the wound, no inflammation being excited by the presence of the needles in the tissues for so short a period of time. These advantages, however, are less manifest at the present time, since the introduction and general employment of antiseptic ligatures, and it is not likely that the procedure will ever again enjoy the popularity which it at one time possessed.

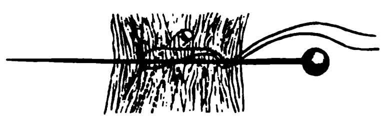

FIG. 35.

ACUPUNCTURE.—An operation which consists in the introduction of needles into the body, either as a means of giving exit to the fluid in œdematous tissues or for the relief of pain in neuralgia and muscular rheumatism. It is a method in great vogue in China, and is used by the physicians of that country not only to assuage pain, but to promote reparative action in ulcers and in the treatment of various other affections. It is said to have been introduced into Europe from China by the missionaries in the seventeenth century. The instrument employed is a round polished needle, having a cylindrical handle of sufficient size to permit of its being readily manipulated by the fingers. It is introduced into the tissues by a quick rotatory movement, and is then left *in situ* for a number of minutes, or even for an hour. Sometimes the insertion of a single needle is sufficient to relieve the pain, but ordinarily half a dozen or more are employed. This little procedure may be practised almost painlessly, and is sometimes wonderfully effective in controlling neuralgic and rheumatic muscular pains. It often fails, indeed, and it seems impossible to determine beforehand in what cases it will prove serviceable, but certainly no case of lumbago or sciatica should be abandoned until acupuncture, as well as the more ordinary remedies, has been tried. In anasarca, when the scrotum and lower extremities are distended with fluid, the patient may experience comfort from a few punctures with a three-cornered surgical needle. The operation should be practised with caution, however, as it is apt to excite an erysipelatous inflammation of the integument. In the treatment of paralysis insulated needles are sometimes used as a means of introducing the electric current into the deeper tissues. This procedure has received the name of *electropuncture.*

There is another form of acupuncture, called *Baunscheidtismus,* which at one time enjoyed a great popular reputation, and which even now is not very infrequently employed. It was devised by a German named Baunscheidt, who is said to have conceived the idea from observing that the irritation caused by the bites of insects afforded him considerable relief from the pain of an articular affection from which he was suffering. The instrument employed consists of a cylinder enclosing a button into which are inserted from twenty to thirty short needles. The open end of the cylinder is placed on the integument, and then by means of a handle the button with needles attached is drawn up into the cylinder compressing a spiral spring: when the handle is released the force of the spring impels the needles suddenly and sharply into the skin. The operation may rest here, or an irritating fluid, such as mustard water or cajeput oil, may be applied to the punctures. This is employed for the relief of neuralgia and muscular pains, and often proves of very great service.

There is still another form of acupuncture, if such it can be called, though it is more nearly related to hypodermic medication. It consists in the hypodermic injection of pure water, and has received the name of *aquapuncture.* Many superficial pains, even though quite severe, may be relieved by this simple procedure. That the relief thus obtained is not merely the effect of imagination, is evidenced by the fact that neuralgias of distant parts are not benefited by aqueous injections, but in order to be effectual the operation must be practised at a point as near as possible to the seat of pain. Aquapuncture is employed in various forms of neuralgia, in lumbago, and in painful functional affections of the abdominal viscera. Bartholow states that he has obtained excellent results from the injection of water into the substance of paralyzed and atrophied muscles. From 2 to 4 gm. (one-half to one drachm) of fluid may be used for each injection, and the operation may be repeated if no relief is experienced at the expiration of two or three minutes.

ADAMS COUNTY MINERAL SPRINGS.—Adams County, Ohio.

POST-OFFICE.—Mineral Springs.

ACCESS.—Via Cincinnati, Portsmouth and Virginia Railroad to Mineral Springs station, thence four miles by carriage to Spring hotel and cottages.

These springs are two in number and flow about sixty gallons of water hourly, having a temperature of 56° F. They issue from the base of a high hill and are surrounded by picturesque and charming scenery. According to a partial analysis by Prof. E. S. Wayne, the water is highly charged with gas and contains 205.35 grains of solid matter per United States gallon, composed as follows: Magnesium chloride, calcium chloride, calcium sulphate, calcium carbonate, sodium chloride, iron oxide, and iodine. The water may be classified as a saline calcic with ferruginous properties. The accommodations for visitors are now quite satisfactory, the hotel having been enlarged and a number of cottages added. The location affords a pleasant retreat for those who seek respite from the cares of business or need the refreshing influences of rural scenery and air. The water has long been resorted to by persons suffering from affections involving the stomach, boweis, and liver. *James K. Crook.*

ADAMS SPRINGS.—Lake County, California.

LOCATION.—Eight miles south of Clear Creek and two miles from Cook's Valley.

ACCESS.—From San Francisco by rail via Oakland Pier, Vallejo, and Calistoga, thence by stage. Commodious quarters have been prepared for guests.

This resort lies among rolling hills which are thickly shrouded with verdant loveliness most of the year. The stage drive from Calistoga lies along a picturesque mountain road hedged in on either side by manzanita copses, scrub oaks, and, higher up, fragrant redwood trees. The elevation is 3,300 feet above the sea level. The following analysis by Dr. Winslow Anderson was made in 1888. One United States gallon contains:

Solids.	Grains.
Sodium chloride	4.64
Sodium bicarbonate	8.07
Sodium carbonate	50.70
Potassium salts	Traces.
Magnesium carbonate	97.90
Magnesium sulphate	Traces.
Calcium carbonate	27.95
Calcium sulphate	1.36

Solids.	Grains.
Ferrous carbonate	0.55
Silica	7.42
Alumina	Traces.
Organic matter	2.60
Total	201.19
Free carbonic acid gas	205.76

In the writer's treatise on the "Mineral Waters of the United States" (1899) this water is classified as an alkaline carbonate. It is cool and sparkling and very grateful to the palate. The resort offers numerous advantages to the seeker after health and recreation. Fogs are rare in Lake County, and the air is uniformly dry and pure, resembling that of Nice in the south of France. The water is stated to be highly recuperative to persons suffering from portal congestion and chronic dysentery. It is further recommended in rheumatism, chronic Bright's disease, and chronic inflammatory states of the female generative organs. Facilities for bathing have been provided. *James K. Crook.*

ADDISON MINERAL SPRINGS.—Washington County, Maine.

Post-Office.—Addison.

Access.—Via steamer from Portland. Hotel and private families accommodate visitors.

This spring is located in a charming hilly section within one-quarter of a mile from an inlet of the Atlantic and about one hundred feet above the ocean level. It is about five feet in diameter and four feet in depth, and has a steady and rapid flow. The following analysis furnished to the writer by Mr. W. H. Nash, one of the owners, was made by Professor Hayes. The figures presumably have reference to grains per United States gallon:

Solids.	Grains.
Potassium sulphate	0.60
Sodium sulphate	0.27
Iron bicarbonate	1.65
Calcium sulphate	0.52
Silica and alumina	Traces.
Calcium bicarbonate	2.65
Magnesium bicarbonate	1.12
Sodium chloride	0.89
Sodium bicarbonate	0.44
Total	8.14

According to the classification adopted by the author, this water is properly termed a light alkaline chalybeate. It has been used with apparent benefit in acid dyspepsia, renal congestion, and other conditions in which a mild antacid diuretic is required. *James K. Crook.*

ADDISON SULPHUR SPRINGS.—Webster County, West Virginia.

Post-Office.—Addison.

Access.—Via West Virginia and Pittsburg Railroad to Cowen; thence by stage twelve or fifteen miles to springs. A railroad now being constructed from a point on the former line will soon extend directly to the springs. Hotels and boarding-houses.

The springs here include two natural fountains and one bored well. Dr. George B. Simpson, of the Webster Springs Sanitarium, in the neighborhood, supplies us with the following partial analysis. One United States gallon contains:

Solids.	Grains.
Calcium carbonate, Magnesium carbonate	13.17
Calcium sulphate, Magnesium sulphate	19.36
Sodium chloride	377.32
Iron oxide	Traces.
Volatile and organic matter	57.45
Total	467.30

We have classified this water as a muriated saline calcic (*vide* "Mineral Waters of the United States"). Mr. R. H. Townsend, of Addison, informs us that it is also heavily impregnated with sulphuretted hydrogen. It has a temperature of 57° F. It has a strong salty flavor, but most persons find it quite palatable.

The town of Addison is picturesquely located on the banks of the Elk River. The situation is about fourteen hundred feet above the sea level, and the surrounding country is of a mountainous character with a variety of pleasing scenery. The place has nine small hotels, but the accommodations are not sufficient to provide for the increasing tide of summer visitors. Statements appear to agree that the waters here possess value in disorders of the alimentary tract and liver. They are of undoubted benefit in cases of chronic constipation and abdominal venosity. *James K. Crook.*

ADDISON'S DISEASE (Bronzed Skin Disease; Melasma Suprarenale).—Of the above terms the first is to be preferred, for while the peculiar discoloration of the skin is not an invariable characteristic of the affection, the credit of Addison to the discovery of the disease called by his name has never been called in question.

Definition.—A disease characterized by progressive asthenia, digestive disorders, pain and tenderness chiefly seated in the epigastric, hypochondriac, and lumbar regions; and an abnormal pigmentation of the skin and mucous membranes.

Historical Notice.—The first case of Addison's disease on record is to be found in Lobstein's treatise, "De nervi sympathici humani fabrica et morbis," Paris, 1823, from the English translation of which, by the late Prof. Joseph Pancoast, I take the following extract: "I have myself observed the nerves forming the suprarenal plexus much thicker in disease, where the capsulæ renales, which were more than twice as large as usual, had degenerated into tuberculous substance." The patient was an unmarried woman, twenty-five years of age, who died in "convulsive spasms analogous to the epileptic. . . . Nothing unusual was discovered in the body of this woman but the aforesaid change in the suprarenal glands, and the enlargement of the nerves."

Notwithstanding the fact that there is no record of any darkening of the complexion, the above was undoubtedly a typical case of Addison's disease, in which, moreover, death by convulsions is not uncommon. The observation regarding the thickening of the nerves in this, the first recorded instance of the disease, is of remarkable interest. The second case was recorded in the "Halle Hospital Reports" by Dr. Schotte, in October, 1828, and is published in vol. vii. of the *Deutsches Archiv für klin. Med.*, by Risel, in the course of his article "Zur Pathologie des Morbus Addisonii." The third case came under the observation of Dr. Richard Bright, at Guy's Hospital, in July, 1829. It is contained in Dr. Bright's classical "Reports of Medical Cases," and also figures as Case V. in Addison's original memoir. The lesions of the capsules were characteristic; there was no other affection of any consequence, and for the first time in the history of this disease it was noted that the "complexion was very dark." A few other cases were reported before the year 1855, when Addison published his work "On the Constitutional and Local Effects of Disease of the Suprarenal Capsules," but it was reserved for his sagacity to detect the relation between the well-marked constitutional symptoms of the affection, the peculiar pigmentation of the skin, and the structural changes in the suprarenal capsules.

It is no disparagement to the memory of Addison to say that the general acknowledgment of his discovery was retarded by his including in his treatise cases which, at the present day, would be rejected from the category of Addison's disease. Of his 11 cases there are but 4 uncomplicated with other affections, 2 complicated; while of the remaining 5, 1 was a case of softening of the brain with advanced kidney disease and tuberculous deposits in various organs, among others in one suprarenal capsule, and the other 4 were cases of widespread carcinomatous deposit, the suprarenal capsules being more or less involved in each. Addison was evidently under the impression that the symptoms of the disease were due to the suppression of the unknown function of the adrenals, and that, therefore, any destruc-

tive lesion of these bodies was capable of causing them. This view of the pathogenesis of the affection has been called in question by distinguished pathologists, who have insisted on restricting the term Addison's disease to a tuberculous inflammation of the adrenals. The original view of Addison, however, is resuming its sway and bids fair ere long to be generally adopted. As will be seen later on, the most reasonable theory of the pathogenesis of the disease is that of adrenal inadequacy.

ETIOLOGY.—Age, sex, and occupation are prominent factors in the etiology of this disease. The lesion of the adrenals being, in the great majority of cases, tuberculous, it follows that the affection is most common during those decades in which tuberculous processes prevail—*i.e.*, between twenty and forty years of age. Exceptionally, the disease may manifest itself both in adolescence and in old age, and it may even be congenital. For example, Belyayeff has reported the case of an infant born with a dingy yellowish-gray skin who died at the age of eight weeks. At the autopsy both adrenals were found in a state of cystic degeneration. The disease is much more prevalent in males than in females, and especially so among the laboring classes. Of 183 undoubted cases tabulated by Greenhow, 119 were males and 64 females, and more than nine-tenths of the whole number were engaged in laborious manual work. Several cases have been associated with psoas or lumbar abscess, the adrenals becoming involved by extension of the inflammatory process. In others devoid of such spinal complication, the origin of the disease has been attributed by the patient to overexertion of the spinal muscles. Such was the fact in one of my own cases, the patient's first symptoms having been weakness and pain in the back immediately following the occupation of weeding her garden. In cases like those last referred to, it is probable that the lesion was well advanced at the time of the overexertion or traumatism, the latter merely serving to awaken dormant symptoms.

SYMPTOMATOLOGY.—To quote the words of Addison: "The leading and characteristic features of the morbid state to which I would direct attention are—anæmia, general languor and debility, remarkable feebleness of the heart's action, irritability of the stomach, and a peculiar change of color in the skin, occurring in connection with a diseased condition of the suprarenal capsules."

Taking these in order, the anæmia first claims attention. As is well known, it was while studying the disease which he termed idiopathic anæmia, now more generally known as pernicious anæmia, that Addison, as he expressed it, "stumbled upon" the discovery of the disease which bears his name. With his mind intent upon the disease which presents the profoundest grade of anæmia, it was natural that Addison should attribute the languor and debility of the bronzed skin disease to a similar state of the blood. The anæmia of that affection is, however, more apparent than real. In one of the most typical cases on record, described and pictured by Byrom Bramwell in his atlas of clinical medicine, the red corpuscles numbered 3,250,000, while the hæmoglobin was present "in at least the normal amount." In another case of the same distinguished clinician the red corpuscles numbered 3,500,000 per cubic millimetre, *i.e.*, 70 per cent. of the normal. These figures certainly do not represent a high grade of anæmia. According to Dr. Wilkes, to whose vigorous and loyal efforts the general recognition of Addison's disease is perhaps chiefly due (Rolleston), anæmia is not a feature of the disease. Under the microscope the red corpuscles are seen to be of normal size and shape, and to form rouleaux as in health, while the white cells may or may not be slightly in excess. In one or two cases free pigment granules are said to have been present, but the observation stands in urgent need of confirmation. Anæmia not being present in sufficient degree to account for the profound asthenia of Addison's disease, to what then is it due? As will be seen under the head of pathogenesis, it is most reasonably to be attributed to an irregular distribution of the blood, to its accumulation in the enormous district of the abdominal vessels.

The languor and debility or, in one word, the asthenia which, according to Addison and all subsequent observers, is a cardinal symptom of the disease, is also one of the earliest. In all histories of the disease the patient has been compelled to abandon his usual occupation by reason of muscular weakness, and when there is no complication with other wasting disease this prostration is unattended, at least in the early stage, with any marked diminution in the volume of the muscular and adipose tissues. The power of resistance to depressing agents is greatly reduced. Mental and bodily exertion which would be regarded by the healthy as trivial, is followed by exhaustion, and the use of purgatives is positively dangerous. As remarked by Bramwell, in more than one of the recorded cases death has resulted from an ordinary dose of a purgative drug.

With this asthenia there is enfeebled action of the heart, of which the apex beat is faint or imperceptible and the sounds weak and distant. The pulse presents varying features, but is always weak and compressible. It may be frequent or infrequent, full or small. Patients are liable to attacks of collapse induced by vomiting, purgation, or other depressing cause, or without apparent cause, which may be so severe as to resemble the collapse of cholera. Contrary to the usual frequency of the pulse in collapse, a remarkable diminution in the number of the heart beats has been observed in several cases (Risel mentions seven), and this without any disease of the brain or important cardiac disease. In a case reported by Cholmeley (*Medical Times and Gazette*, 1869, vol. ii., p. 219) in which death was preceded by profound collapse, dyspnœa, and convulsions, the pulse fell to 36 per minute.

Symptoms referable to disordered digestion are always more or less prominent and are of early appearance. Among them are marked anorexia, nausea and vomiting, constipation alternating with diarrhœa, and epigastric tenderness. Sometimes the nausea and vomiting occur in paroxysms without any apparent exciting cause, and on this account, as well as because of their severity, they have been compared to the gastric crises of locomotor ataxia. Epigastric tenderness was a prominent feature of two cases that came under my care at the Episcopal Hospital of Philadelphia. In the report of the first I noted that "at times there was great tenderness about the umbilical region, and on one occasion, after palpating the abdomen, the patient uttered loud cries for ten or fifteen minutes and seemed in great agony" (Trans. Path. Soc. Phila., vol. v.). In the other case, "the pain was latterly most severely felt in the left lumbar region, in which situation there was also a great degree of tenderness on pressure" (Trans. Path. Soc. Phila., vol. x.). In the first of these cases nothing was found at the necropsy to account for this remarkable tenderness; in the second, it might have been due to the great tumefaction of the lumbar glands.

The date of the appearance of the pathognomonic discoloration of the skin from which the disease derives one of its names is very variable. It may either precede or follow the constitutional symptoms, or the disease may terminate fatally without its manifestation. Greenhow has collected a number of cases illustrating the erratic appearance of this, the only pathognomonic feature of Addison's disease. In one of his cases the pigmentation of the skin is said to have been the sole symptom for eight years, at the end of which period the pigmentation deepened and the other well-known symptoms of Addison's disease were superadded. This case is the most remarkable on record in so far as the early appearance of bronzing is concerned, but it has been criticised by Bramwell, who has shown that the original pigmentation, limited to the forehead and parts adjacent, was probably due to a chronic peritonitis, of which the signs were found at the autopsy, and that the genuine melasma suprarenale dated from the period when the pigmentation was observed to deepen and become more general, and the constitutional symptoms to develop.

In connection with the statement above made, that the disease may terminate without cutaneous change, it

is important to observe that the pigmentation may be very limited in area, and so situated as to escape observation unless the entire surface of the body is minutely inspected. The most remarkable illustration of this important point is furnished by Bramwell. He had exhibited at his clinique in the Edinburgh Royal Infirmary, a patient whose chief symptoms were moderate anæmia (3,500,000 red corpuscles per cubic millimetre), emaciation and extreme prostration, and had confessed his inability to make a positive diagnosis. As the patient was walking away to put on his clothes, "and when a good light fell full on his back, I noticed," says Bramwell, "two or three brown discolorations over the spines of some of the dorsal vertebræ. It immediately flashed across my mind that the case was one of Addison's disease. I at once called the patient back and carefully examined the mucous membrane of the mouth. A small brown discoloration was seen to be present on the inner side of the left cheek, just opposite the angle of the mouth. The discoloration was quite characteristic, and I immediately committed myself to a positive opinion that the case was one of Addison's disease."

The abnormal surface pigmentation has its seat in the skin and in the mucous membrane of the buccal cavity, including that of the tongue; it has been said also to occur in the vagina and the conjunctiva. The pigment is deposited in the youngest layers of the rete Malpighii, in contact with the papillæ. It appears both as a diffuse coloration of the cells and also in the form of distinct granules in the cells, or free; in the latter case it is supposed to be left after the dissolution of the cells. It rarely appears in the corium, although sometimes branched pigmented connective-tissue cells are found. The parts of the external surface most deeply pigmented are those which, under normal circumstances, are the seat of oft-recurring hyperæmia, either from atmospheric influences or friction, such as the cheeks, neck, and backs of the hands. There is also a special tendency to the deposit of pigment in those parts where it is found normally in greater amount than elsewhere, such as the nipples, genital organs, and axillæ. In well-marked cases, it pervades the entire cutaneous surface, being deeper in the parts above mentioned, and may be deposited in the lunulæ of the nails and even in the teeth. The hair and the iris have been observed to grow darker with the progress of the disease. The tint of the discoloration varies in different cases, depending to some extent upon the normal complexion of the patient. It is most striking, because of its incongruity, when the patient is naturally fair, with light hair and blue eyes. The color of the most typical cases of the disease may be best imitated by staining the healthy skin with walnut juice. In chronic cases, the complexion may come to resemble that of a mulatto, as in the portrait illustrating Bramwell's classical monograph ("Atlas of Clinical Medicine," vol. i.) which has been copied far and wide. When the pigmentation is partial, as it is apt to be in its early stage, its outline is not sharply circumscribed, as in other pigmentary affections, but gradually fades into the surrounding integument. Upon the darker patches also are frequently seen black specks resembling moles or freckles. As above stated, the pigmentation is most pronounced in parts that have been subjected to any species of irritation, such as that of a blister, or that produced by the pressure of garters, waist-bands, or suspenders. A well-known illustration of this effect of cutaneous irritation is afforded by the case of a baker's boy whose shoulders were marked with dark stripes corresponding to the lines of pressure of straps from which his basket was suspended.

Pigmentation of the mucous membranes is at least equal in diagnostic value to that of the skin, although it is believed by most authorities to be rarer and to occur at a more advanced stage of the disease. It is most frequently observed in the line of closure of the lip, and upon the tongue, cheeks, and gums, and is accented by any cause of irritation, such as that of a carious, jagged tooth. When seated in the gums the discoloration has been mistaken for that of lead poisoning. It may be of a dingy brown hue or darker, as if caused by ink stains. It has also been compared to the stains produced by whortleberries and blackberries. In one of Bramwell's cases the pigment was accumulated in round, ball-like masses on the under surface of the tongue parallel with and apparently adherent to the lingual arteries.

The urine presents no characteristic changes. The most careful study of the urine in any single case was made by Dr. Thudicum, for sixty-five consecutive days, in a patient of Dr. Burdon Sanderson. Without complicating fever or diarrhœa, there was a great diminution in the daily amount of urine, it being reduced more than one-half; the specific gravity was 1.020 and upward, and the reaction acid. The most important result of these researches was the determination of the fact that the urinary pigments were much diminished. Thudicum's analyses, so far as the estimate of the urinary pigments is concerned, have been since confirmed by Drs. A. E. Garrod and Dixon Mann. Thudicum was apparently of the opinion that the diminution in the amount of the urinary pigments might bear a relation to the excess of pigment in the skin; but it is more reasonable to suppose that if disease of the adrenals caused an accumulation of soluble pigments in the blood, the coloring matters of the urine, supposing the kidneys to be healthy, would be present in excess.

The remaining symptoms of Addison's disease are either inconstant or negative, and, therefore, of secondary importance. Most of them are referable to the nervous system and are dependent upon a defective or irregular supply of blood. Among them may be mentioned insomnia and somnolence, headache, vertigo, tinnitus aurium, neuralgic pains which may be seated in the joints, muscular twitchings, and epileptiform convulsions. The latter, associated with delirium and coma, may be the immediate precursors of death.

The temperature throughout the disease presents nothing characteristic, being, in the absence of complications, normal or subnormal. The nutrition in the earlier stages may be well maintained, and in uncomplicated cases there may be little loss of fat throughout the entire course of the disease. When associated with phthisis, however, or other wasting disease, and even sometimes without such association, emaciation may become extreme.

PATHOGENESIS.—There are two principal theories of the pathogenesis or "pathological physiology" of Addison's disease: 1, The nervous theory; 2, the theory of adrenal inadequacy.

1. *Nervous Theory.*—According to this theory, "the symptoms of Addison's disease are not directly due to the destruction of the suprarenal bodies, but result from the derangements in the abdominal sympathetic (and perhaps other nervous structures) which the lesion of the suprarenal capsules produces." This theory has, to support it, facts derived both from anatomy and from physiology. In the great majority of cases the nerves and ganglia of the abdominal sympathetic are extensively involved in the tuberculous inflammation which destroys the adrenals, and it is only reasonable to suppose that such involvement must give rise to serious symptoms. In addition, it has been demonstrated by Alezais and Arnaud that upon, and in the substance of, the capsule of the adrenals there are numerous sympathetic ganglia. These they term the *pericapsular nervous ganglia*, and they hold that the peculiar and special lesion of Addison's disease "is their degeneration." They explain the well-known absence of symptoms of Addison's disease in many cases of cancerous disease of the adrenals by the fact that the malignant growth advances from within outward and is limited by the fibrous covering of the glands, whereas tubercles invade both gland and fibrous covering alike. Semmola, of Naples, pushes the nervous theory to the extreme of holding that the abdominal nerves and ganglia are primarily involved, and that the lesion of the adrenals is a trophic result of their functional disturbance.

Granting, as every one does, the common involvement of the abdominal nerves and ganglia, and especially that

of the *pericapsular ganglia*, it remains to be considered whether the results of experiments upon the abdominal sympathetic throw any light upon the pathogenesis of Addison's disease.

Irritation of a sensory nerve produces vasomotor paralysis in the irritated region, and the well-known experiments of Goltz ("*Klopfversuch*") have shown that irritation of the intestines produces complete vasomotor paralysis of their blood-vessels, causing thereby so great an accumulation of blood that the animal shows symptoms of syncope, the same as if it had been bled copiously.

The irritation of the numerous nerves and ganglia of the adrenals produced by inflammation with new formation of tissue and subsequent softening, such as exists in Addison's disease, is transmitted to the semilunar ganglion and solar plexus from the beginning of the deposit in the adrenals, and, later, by extension of the inflammatory process to these nerve centres. By this means a vasomotor paralysis of the intestinal vessels is produced, as in the experiments of Goltz, except that, unlike in the latter case, it is constant. This continual hyperæmia of the intestinal vessels leads to enlargement of the solitary glands and Peyer's patches, so constantly found in Addison's disease, and occasionally to catarrh and ulceration of the stomach and intestinal mucous membrane. It accounts for the dark color of the liver, spleen, pancreas, and kidneys so often observed, as well as for the brownish hue of the peritoneum noticed in a few instances. Indirectly, it explains the anæmic and dry condition of other parts of the body, and directly accounts for the great muscular weakness, syncope, gastro-intestinal disturbance, dyspnœa on slight exertion, and small radial pulse. These symptoms have been attributed to a high grade of anæmia, such as exists in pernicious anæmia; and this is due to the fact that many of the symptoms in the two affections are identical. Repeated examinations of the blood have, however, demonstrated that the reduction in the number of the red corpuscles in Addison's disease is trivial compared with that found in pernicious anæmia. The symptoms resembling those of pernicious anæmia—such as dyspnœa on slight exertion, syncope on assuming the upright posture, rapid, small, and feeble pulse—are attributable to an insufficient supply of blood, albeit of fair quality, to the supradiaphragmatic portion of the trunk.

From the foregoing, it is manifest that there are well established facts, both anatomical and physiological, in support of the nervous theory of Addison's disease. This is the theory adopted by Bramwell, although he qualifies his adherence to it by the statement that it is "perhaps possible that some of the symptoms of Addison's disease may be the direct result of abolition of the [glandular] function of the suprarenal capsules."

Rolleston (*British Medical Journal*, April 6, 1895) discards the nervous theory rather summarily, and chiefly, as it seems to the writer, on the ground that the "sympathetic in the neighborhood of the suprarenal bodies is not constantly altered." It must be recalled, however, that Alezais and Arnaud discuss this contingency, and claim that Addison's disease is "accompanied with alterations in the pericapsular sympathetic nervous system and with complete integrity of the rest of the solar plexus and its ganglia."

2. *Theory of Adrenal Inadequacy.*—The arguments in support of this theory are derived from analogy, anatomy, therapeutics, and experimental pathology.

The structure of the adrenals is distinctly glandular. In the vast majority of cases, the symptoms of Addison's disease are associated with destruction of these glands. In the rare cases in which they are destroyed by disease without concomitant symptoms of morbus Addisonii, the absence of the latter may be due to accessory suprarenal bodies or to suprarenal "rests." The former, according to Rolleston, are "very commonly present in the connective tissue in the immediate neighborhood of the two organs"; the latter, the so-called "suprarenal rests," are found "embedded in the kidney or liver." The analogy with myxœdema is thus seen to be very close, and, to make it complete, it need only be added that the life of an animal whose adrenals have been removed may be prolonged by embedding beneath its skin a healthy adrenal or administering subcutaneously an adrenal extract.

The experiments upon the function of the adrenals which seem to the writer to be the most free from criticism are those of Abelous and Langlois (*Archives de physiologie*, tome iv., 1892). These observers found: (1) that the total destruction of both adrenals in frogs was invariably followed, sooner or later, by death, the time of which depended upon various factors. Frogs in a state of hibernation survived the operation for twelve or thirteen days, while in the summer the animals never lived longer than forty-eight hours. If the animal was irritated so as to excite active muscular movements, it perished sooner than if it were allowed to remain quiescent. In other words, the more active the nutritive changes, the sooner the animal died—a fact in accordance with the longer survival of hibernating animals as compared with those operated on during the summer.

(2) The destruction of one adrenal did not cause death or any abnormal manifestation (six animals operated on).

(3) If one adrenal is destroyed and a large portion of the other, the animal may or may not die. A considerable portion (*un fragment notable*) of one adrenal must be left in order to insure the survival of the animal.

(4) The insertion beneath the skin (in the dorsal lymph sac) of the adrenals taken from a sound frog prolongs the life of a frog from which both adrenals have been removed.

(5) The injection (subcutaneous) of adrenal extract into frogs from which the adrenals have been removed prolongs their lives but a short time—not more than twenty-four hours.

(6) The injection (intravenous or subcutaneous) of blood from a frog about to die from the effects of loss of adrenals into a frog from which the adrenals have just been removed, causes rapid paralysis and death. The same injection into a normal frog produces very slight and transitory disturbances.

In none of their experiments did Abelous and Langlois observe any anomalous pigmentation.

They conclude from their experiments, of which the above is but an abstract: (*a*) that the death of frogs after removal of their adrenals is due to the accumulation in the blood of one or more toxic substances; (*b*) that this substance, or these substances, produces an effect resembling that of curare, acting chiefly upon the terminations of the motor nerves and slightly also upon the muscles. The rôle of the adrenals, in their opinion, is to destroy this poison by an internal secretion which they elaborate.

So much for the theory of adrenal inadequacy, which is the one adopted by Rolleston, who concludes his elaborate and masterly discussion of the pathogenesis of Addison's disease (Goulstonian lectures, *British Medical Journal*, 1895) with the statement that the affection "is due to an inadequate supply of suprarenal secretion. Whether the deficiency in this internal secretion leads to a toxic condition of the blood, or to a general atony and apathy, is a question which must remain open."

More careful observation is needed to determine whether the symptoms of those cases of Addison's disease in which the sympathetic nerves and ganglia are implicated, are different from those in which they are not. Judging from the well-known results of physiological experiment, it would seem reasonable to expect a greater degree of asthenia and a greater tendency to syncope in cases of sympathetic involvement, and, on the other hand, to expect a predominance of more purely toxic symptoms in those cases (the type of which is simple atrophy of the adrenals) in which the lesion is limited to the capsules. The supreme judge of this question, as of all questions of pathogenesis, is the clinician, and with greater opportunities for observation, the expectation of its solution is not unreasonable.

DIAGNOSIS.—When the disease is primary, the constitutional symptoms well marked, and the discoloration of

skin and mucous membranes present, the diagnosis presents little or no difficulty to one who has previously studied a single case of the disease. On the other hand, when the constitutional symptoms are well pronounced in a primary case, and the bronzing of skin is not yet developed, the diagnosis is to be made only, if at all, by the exclusion of other wasting diseases, especially cancer of abdominal organs and progressive pernicious anæmia. Many years ago there came under my care at the Episcopal Hospital of Philadelphia a case of lumbar abscess with several open sinuses leading to carious vertebræ. The general surface of the body was of a dark dingy hue, and the orifice of each sinus was surrounded by a broad, deeply pigmented ring. The patient had been previously at another institution, where secondary disease of the adrenals had been suspected. The autopsy showed these bodies to be perfectly healthy and the kidneys to be involved in extensive amyloid degeneration. A dingy discoloration of the skin is not uncommon in amyloid disease of the kidney, as first pointed out by Grainger Stewart.

The discoloration of skin, although not the most essential characteristic of the disease, is justly regarded as its most important diagnostic feature. It is to be distinguished from melasma gravidarum, pityriasis versicolor, lichen, and pigmentary syphilides, and this is readily done by any one familiar with these affections. The melanoderma of phthisical patients presents more serious difficulty. Although the latter is often confined to the face and does not invade the mucous membrane of the buccal cavity, the difficulty is a real one, and is augmented by the fact that pulmonary tuberculosis is the most frequent complication of Addison's disease. The seat of the melasma suprarenale, or its greater intensity, upon the face and neck, the dorsum of the hands, areola of the nipple and about the umbilicus, in the axilla, groin, and upon the genitals, is characteristic. Other diagnostic features of the pigmentation have been described above under the head of Symptoms. A discoloration of the skin liable to be confounded by the inexperienced with that of Addison's disease is sometimes seen in badly nourished paupers of dirty habits, whose skin is the abode of vermin. This pigmentation shows itself in the form of patches separated by healthy skin; the epidermis is often roughened, and the discoloration more marked upon the trunk than on the face and hands. The skin is also often marked with scratches, the result of the intense itching. Under the microscope, the particles of pigment in this affection are found in all the layers of the epidermis, instead of being limited, as in Addison's disease, to the deeper layers of the rete Malpighii. The pigmentation of chronic malarial poisoning is distinguished from that of Addison's disease not only by its distribution, but by the history of the case and the frequent presence of splenic enlargement; chronic icterus, with which Addison's disease was formerly confounded, is distinguished by the presence of pigment in the ocular conjunctiva and in the urine.

Other discolorations of the skin simulating closely the pigmentation of Addison's disease are mentioned by systematic writers, but are so rare as to be in themselves pathological curiosities. Among them may be mentioned a diffuse pigmentation associated with chronic scurvy (Bramwell), and a few other cases of melasma occurring without obvious cause. According to the author just cited, there are certain forms of pigmentation of the skin associated with chronic peritonitis, or malignant disease of the abdomen or pelvis, which it is impossible to distinguish from Addison's disease. This fact, though discomfiting to the clinician, is of great interest to the pathologist, as tending to prove that the most characteristic symptom of the affection, the melasma suprarenale, is to be attributed rather to the implication of the abdominal sympathetic than to that of the adrenals.

PROGNOSIS.—The prognosis is in the highest degree unfavorable, although recoveries of cases presenting every sign and symptom of the affection have been reported by the most competent observers. Among these may be mentioned Sir William Gull and Dr. Finney. In making predictions as to the duration of life, the remittent character of the disease should be borne in mind. A case seen during a period of exacerbation may lead to the prognosis of a speedily fatal result, but the worst symptoms may disappear and be followed by a prolonged period of remission. The average duration of the life of hospital patients who, as a rule, do not apply for treatment until forced to acknowledge the fact of their illness, has been estimated at two years. Sudden death without preceding exacerbation is sometimes observed, the fatal result being apparently due to syncope.

TREATMENT.—At the present time, there may be said to be a specific treatment of Addison's disease—that with adrenal extract. This fact, however, in no way diminishes the importance of general therapeutic measures, of which the most important are the following: The cessation of work is the first thing to be insisted upon in the way of treatment, and during the exacerbations strict confinement to bed. An immediate mitigation of the symptoms has often followed the admission to hospital of a patient who, up to that time, had been endeavoring to resist the gradually increasing asthenia. A moderate amount of stimulants is generally well borne, but cod-liver oil, which might seem appropriate on account of the tuberculous nature of most cases of the disease, is, as a rule, not tolerated. Remedies to allay irritability of the stomach are frequently indicated, such as ice, lime water, carbonic acid water with brandy, bismuth, creosote, hydrocyanic acid, and small doses of opium. Massage and faradization are well worthy of a trial in order to derive the blood from the abdominal vessels. Iron and arsenic should be employed tentatively and will be generally found useful, and the same is true of nux vomica and its derivatives. Cathartics are to be avoided, as profound depression has often followed their employment in this disease. When constipation is troublesome it should be relieved by enemata and suppositories. The diet should be simple but nourishing, consisting of soups, milk, eggs, meat jellies, koumyss, and the like.

Treatment with Adrenal Extract.—The success that has attended the use of adrenal extract is such as to make it imperative in all cases of Addison's disease. This is not a mere *obiter dictum*, but is the result of a careful study of many of the reports upon the subject. A few examples will suffice to show the kind of evidence on which the administration of the adrenal extract is based.

Osler (*International Medical Magazine*, February, 1896) reports a case in which there was marked improvement under the use of the extract, attended with considerable gain in weight and restoration of general vigor. The pigmentation, however, which was of advanced grade, had not diminished except on the palate. A case is reported by Suckling (*British Medical Journal*, May 28, 1898) in which the symptoms and signs were well pronounced except pigmentation of mucous membranes, of which there is no mention. Tablets of suprarenal extract (āā gr. v.) were given to the extent of from twenty to thirty-five daily. In the course of a year recovery was complete with disappearance of melanodermic and leucodermic patches. Kinnicutt has tabulated 48 cases (*American Journal of the Medical Sciences*, July, 1897) treated with adrenal preparations. "Six patients are reported as cured or practically well, 22 improved, 18 unimproved, and in 2 instances an aggravation of the symptoms is stated to have occurred during treatment." In the second class of cases, those in which improvement took place, the improvement was but temporary; but this was as much as could be expected, since in many the disease of the adrenals was associated with grave tuberculous lesions in other parts of the body.

On the theory that Addison's disease is chiefly due to suppressed function of the adrenals, the use of adrenal extract would find its most successful employment in those cases in which the lesion consists of simple atrophy or fibroid degeneration. *Frederick P. Henry.*

ADENITIS. See *Lymphatic Glands, Diseases of.*

EXPLANATION OF
PLATE VI.

EXPLANATION OF PLATE VI.

FIG. 1.—Shows the Discoloration of the Tongue in a Case of Addison's Disease. *a*, Dark ink-like stains near the free border of the tongue; *b*, fungiform papillæ on the dorsum of the tongue, discolored by deposit of pigment; the papillæ circumvallatæ remaining uncolored.

FIG. 2.—Section of Pigmented Patch on the Tongue, Viewed with a One-Inch Objective. The lower, plumper cells clothing the papillæ are seen loaded with pigment; the subepithelial connective tissue remaining quite uncolored.

FIG. 3.—Section of Bronzed Skin. *a*, Rough scarf skin free from pigment; *b*, plumper cells of the rete mucosum, the deepest layer loaded with pigment; *c*, subepithelial connective tissue free from pigment.

FIG. 4.—Section of Discolored Patch of Skin, Site of a Recent Blister. *a*, Brown pigment deposited in the deeper layers of the epidermis; *b*, scattered masses of pigment situated in the cutis vera.

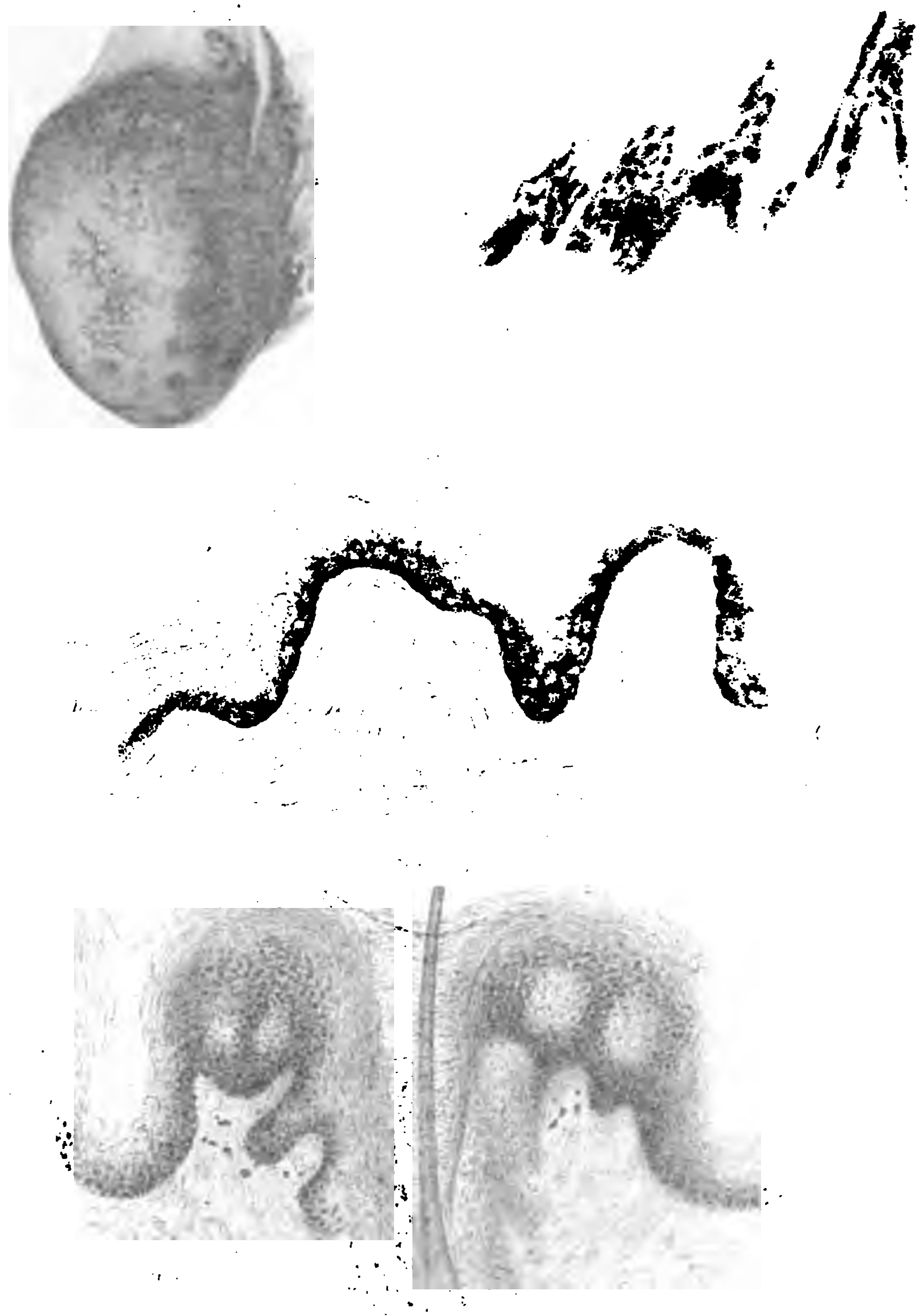

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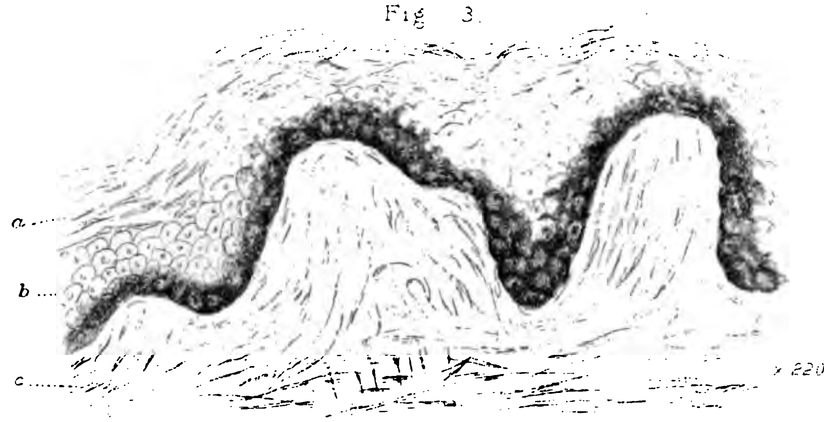
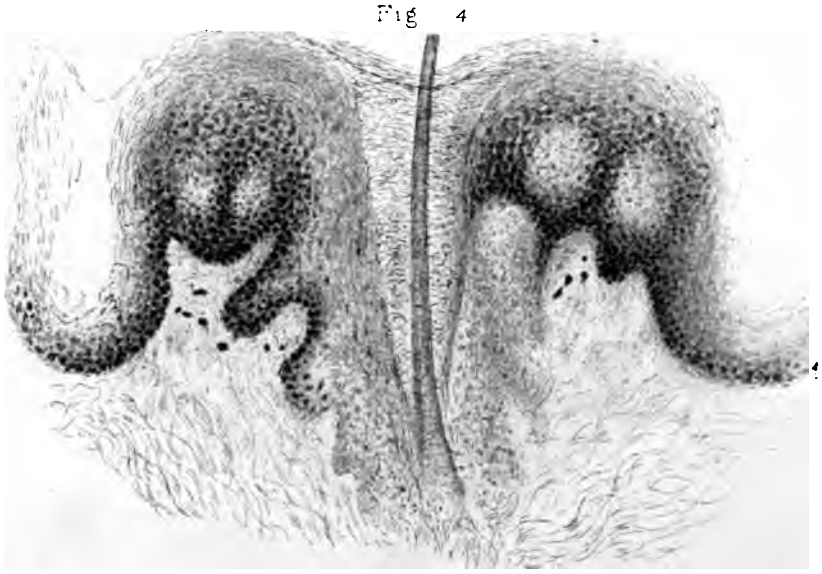
PLATE VI.





PIGMENTATION OF THE SKIN AND OF THE MUCOUS MEMBRANE OF THE TONGUE OBSERVED IN ADDISON'S DISEASE.—*(Copied from the Treatise of Edward H. Greenhow, M.D., F.R.S.)*

H Ford sc

ADENO-CARCINOMA. See *Carcinoma.*

ADENO-CYSTOMA. See *Cystoma.*

ADENOID VEGETATIONS. See *Tonsils, Pharyngeal.*

ADENOMA.—Adenoma is the term applied to a new growth originating in glandular epithelium and corresponding in histological structure with the general type of gland tissue.

Every new formation of glandular tissue, every glandular hyperplasia, cannot be regarded as an adenoma, and sometimes it is impossible to say whether an apparent growth is a simple hyperplasia or a tumor. A gland which is increased in size in consequence of excessive nutrition and function cannot be called an adenoma, but must be considered a hyperplasia.

In the same way must be considered those formations in mucous membranes which frequently develop in consequence of chronic inflammation and take the form of tumors. These are local new formations which project above the surface in the form of polypi or papillary masses. The new growth commences in the connective tissue, and the epithelium also takes part in that, by the increase of the surface, the covering epithelium also must increase. If there are glands present their ducts are usually obstructed, and cysts are formed with papillary projections within them. This must be considered simply as a growth due to chronic irritation, and as entirely distinct from the true glandular polyp of the mucous membranes in which a formation of new glands actually occurs. Clinically, these can usually be distinguished, for the simple polyp disappears when its cause, chronic irritation, disappears.

Etiology.—The causation of adenomata is obscure, though probably no more so than that of new growths in general.

In some forms congenital misplacement of tissue elements appears to play an important part. Thus in the kidney, adenomata sometimes are found which correspond in structure to the adrenal. These, as pointed out by Grawitz, develop from aberrant remnants of the adrenal embedded in the kidney substance. This is also true of adenomata corresponding to the structure of the mamma occasionally seen in the axilla, and of the rather unusual substernal tumors in which a tissue similar to that of the thyroid body is found. Here it is probable that the theory of embryonic remains of Cohnheim gives the true explanation: the tumor in each of these instances develops from embryonic fragments which become separated from the gland in its development. Although in certain locations, as the stomach and rectum, the adenomata appear to bear out Virchow's irritation theory, in other locations they offer it no support at all.

The parasitic theory receives absolutely no support from the adenomata, for it is impossible to conceive of a vegetable or an animal parasite causing the reproduction of definite gland tubules.

Varieties and Structure.—The appearance of adenomata varies greatly with their location. Naturally, any particular cell or arrangement of cells cannot be described as peculiar to this tumor, any more than any type of cell can be regarded as characteristic of all physiological glandular structures. The adenomata differ from one another in structure as much as the structure of the liver differs from that of the lachrymal gland.

In the stomach, intestine, and uterus, in a general way, the epithelial cells are arranged as tubular acini with a central lumen, the cells generally occurring in one layer, though there may be more. The acini are separated from one another by connective tissue in which the blood-vessels and lymphatics are borne. Why the cells in their growth should grow as tubules instead of breaking through the basement membrane and forming atypical groups of epithelial cells, as is seen in the form known as adeno-carcinoma, is difficult of explanation. It is probable that the inherent tendency thus to develop is not early influenced by their altered environment. That they do not break through and grow as carcinoma is frequently seen in some large and rapidly growing adenomata. The cells lining the tubules may be columnar or cuboidal, according to the gland from which the tumor develops.

In addition to the tubular form there is an uncommon variety, the racemose adenomata, in which the appearance is that of a complicated gland structure with closely aggregated acini of circular outline containing columnar, cuboidal, or polyhedral cells.

Then, again, in the liver, kidney, and adrenal occur adenomata resembling more or less closely the normal structure of those organs.

As in any other epithelial tumor, the relation between the epithelial cells and the connective tissue varies. When the development of the connective tissue is excessive, far beyond that of the normal gland, it must receive some recognition in naming the tumor, for it is as truly new formed as is the epithelial portion: in such cases it is called an adeno-fibroma. When this connective tissue is especially abundant in cells and represents an embryonic tissue, the term adeno-sarcoma is used. In the ovary occurs an adenoma in which the acini line cyst cavities. This is termed an adeno-cystoma.

Adenomata, as far as known, do not contribute to the body metabolism. That there is a partial preservation of function is occasionally seen. In the adenoma of the liver sometimes a biliary pigmentation occurs; in the adenoma of the breast there may be a secretion of milk-like fluid; in the adenoma of the intestine the tubules may contain mucus; in the adenoma of the thyroid colloid material may collect. But these substances remain in the tubules in which they are formed, and take no part in the general metabolism.

Secondary Changes.—All forms of degeneration are common in adenomata. Hyaline transformation may give the tumor an appearance justifying the term "cylindroma." This, however, is rare. Myxomatous and calcareous degenerations occasionally occur. Cystic change may result from gradual dilatation of the glandular acini. Hemorrhages are common, and on free surfaces ulceration is frequent.

The most important change, however, is a carcinomatous transformation. This is especially common in the stomach, intestine, and uterus. The proliferation of the epithelial cells becomes excessive; the acini become more abundant and irregular; the cells depart from their tubular arrangement and grow as solid epithelial masses outside the acini, forming an adeno-carcinoma, or, as Ziegler named it, *adenoma destruens.* The growth may eventually become purely carcinomatous, but it usually retains more or less its adenomatous type.

General Character.—The rapidity of growth of an adenoma differs in various parts of the body in which it has its seat, and the same holds true for its malignancy. There are few which can be considered as strictly benign tumors. The pure adenoma seen in the liver may form metastases in the spleen and less frequently elsewhere. Fatal metastases from adenomata of the thyroid have been reported. In the sweat, sebaceous, and lachrymal glands the tumor usually grows slowly, remains local, and may be considered benign. In some locations, although adenomata never produce metastases, they may endanger life by their size, as in the ovary; or may obstruct important canals, as in the intestine; or may cause great disfigurement, as displacement of the eye in adenoma of the lachrymal gland. The general health may also be influenced by interference with the normal function of the organ in which they are located, or in consequence of ulceration and hemorrhage. There are few tumors more malignant than the adenomata of the intestinal tract. They extend rapidly, infiltrating all coats of the intestine, and frequently produce metastases in the liver. Their malignancy does not always depend on carcinomatous transformation, for some of the most destructive tumors of this canal are pure adenomata.

As regards the terms Malignant Adenoma and Adeno-carcinoma, it seems best to use the former in designating those growths in which, although there is extensive infil-

tration of surrounding tissue and even the formation of metastases, the tumor still retains its glandular type; and to use the term Adeno-carcinoma for those forms in which the cells depart from the tubular arrangement with the formation of distinct cancerous areas.

FIG. 36.—Benign Adenoma of Small Intestine. × 10 diameters.

The principal locations in which adenomata may occur and brief descriptions of their characteristics dependent on location and origin are given below:

SKIN.

Adenomata of the skin are rare. They may develop from the sebaceous or from the coil glands. They grow slowly and are practically always benign. Adenomata of sweat glands are found in various parts of the body, but principally on the face, where they are of a dirty grayish-white color with nodular surface. Histologically, coils of dilated ducts are seen, from which degenerated epithelium can be squeezed. Campiniri (1895) describes cystic and carcinomatous changes in such tumors. Adenomata of sebaceous glands appear principally on the face and are usually of congenital origin. They appear as small, roundish, convex papules, of bright color, and in old people are often associated with fibromata.

Whitney has described an adenoma of sebaceous-gland origin which was the size of an orange and contained large cavities filled with a material resembling butter in its color, consistence, and general appearance. (Consult also the special article on *Adenoma of the Skin.*)

MUCOUS MEMBRANES.

Mouth.—Adenoma of the mucous glands of the mouth is very rare. It occurs as isolated nodes and in some cases gives rise to macrocheilia. Adenomata of the salivary glands have been reported.

Larynx and Bronchi.—A few cases have been reported of benign adenomata arising from the mucous glands of these organs. Eber (1896) has reported several cases in the bronchi of sheep. They occur as irregular nodular growths.

Stomach and Intestine.—Small, apparently benign adenomata are sometimes seen. The malignant adenomata and the adeno-carcinomata are the most important forms. They start as soft nodular growths which break down readily and ulcerate. They infiltrate all coats and may cause perforation. Metastases in the liver may occur, and there is sometimes a direct extension to adjacent organs, as from stomach to pancreas. In the large intestine, of all forms of new growth, this tumor is the most common cause of chronic intestinal obstruction. Histologically, they may be made up of dilated, irregularly branching tubules presenting a single layer of cylindrical epithelium—in the stomach originating from the gastric tubules, in the intestine from the glands of Lieberkühn; or in addition to this structure there may be irregular solid masses of epithelium, the result of great proliferation of epithelial cells and destruction of the basement membrane.

In the large intestine the locations, in order of frequency, are the rectum, the sigmoid, splenic and hepatic flexures of the colon, and the cæcum.

In the small intestine adenoma is occasionally found in the duodenum at the papilla marking the orifice of the bile duct.

Vulva.—Benign adenomata arising from the glands of Bartholini have been reported. Kelly describes an adeno-carcinoma, as large as an orange, of the vulvo-vaginal glands.

Urinary Bladder.—Adenomata of this organ are rare. They may be sessile or pedunculated, smooth or lobular, benign or malignant. It is not easy to explain their origin.

Uterus.—Adenoma originates generally in the body of the uterus, but occasionally in the cervix. It may rapidly infiltrate the myometrium and may produce nodules on the peritoneal surface. It has the usual glandular structure and a small amount of fibrous stroma. Carcinomatous areas may develop.

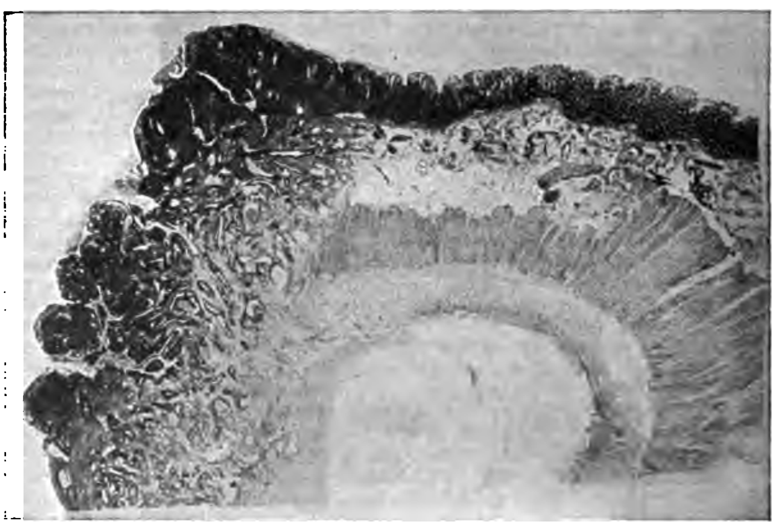


FIG. 37. Malignant Adenoma of Rectum. × 10 diameters.

Occasionally a benign polypoid adenoma may be seen, but it is often difficult to distinguish this from a hyperplastic glandular endometritis.

FIG. 38.—Malignant Adenoma of Rectum. Greatly magnified in order to show character and arrangement of the newly formed glands.

Diffuse benign adeno-myomata of the uterus have been carefully described by von Recklinghausen and Cullen.

ADENOMA IN SOLID VISCERA.

Liver.—Adenomata of this organ are rare. They may occur in the normal or in the cirrhotic liver, and appear as small, grayish-white, reddish, or brown miliary solitary or multiple areas. They are made up of tortuous, branching, gland-like tubules of newly formed trabeculæ of liver cells, not arranged as typical liver lobules. The cells are large, pale, and finely granular. They arise from proliferation either of liver cells or of the cells of the bile capillaries. The larger ones have a distinct capsule. Some writers believe that they may become carcinomatous.

Another and rare form is the adenocystoma, which is made up of cysts containing a colorless fluid, the walls of the cysts being covered by glandular epithelium. This form probably originates from the bile ducts.

Kidney.—Congenital adenoma, struma aberrata suprarenalis.—As shown by Grawitz, this tumor develops from fragments of the adrenal body which in the development of the kidney become incorporated in its substance. The tumor is small, grayish, and generally just beneath the capsule. Histologically, it consists of large pale epithelial cells arranged in tubules similar to those of the cortical portion of the adrenal. The cells are filled with fat granules. Active proliferation may occur with tendency to malignancy. The observations of Askanazy and Lubarsh indicate that malignant tumors resembling carcinomata may develop from these growths.

Adenomata arising from renal tubules are rare. They originate in the convoluted tubules, and appear as very small nodular masses, though they sometimes may reach a diameter of 3 to 4 cm. They are distinctly encapsulated. The cells may be cuboidal or may become cylindrical, and are arranged in the form of single tubules; the glomeruli and different types of tubules are never reproduced.

A *papilliferous cystic adenoma*, a small tumor with fibrous capsule in which the lining epithelium is elevated in a papillomatous manner, is occasionally seen.

Adrenal.—Adenoma of adrenal, or struma lipomatosa suprarenalis of Virchow, generally develops from the cortex as an irregular nodular growth, yellowish or pale brown in color. It may remain small or may completely destroy the organ, sometimes attaining a very large size. The cells resemble those of the normal gland in structure, but are large, pale, and granular, as though filled with fine fat granules.

Breast.—Many tumors of the breast combined with the formation of cysts have been described under the name of adenoma. In such cases the tumor is generally a fibroma or a sar-

FIG. 39.—Fibro-Adenoma of Mammary Glands.

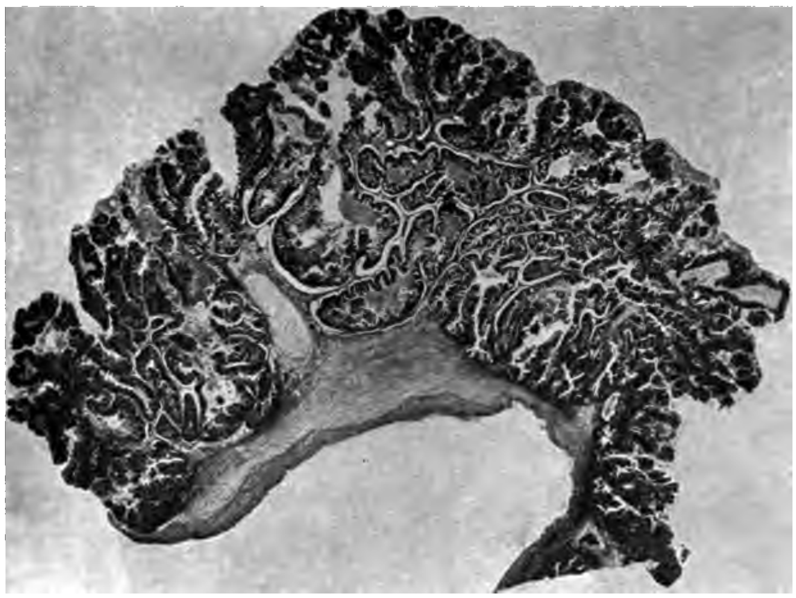


FIG. 40.—Papillary Adeno-Cystoma of Ovary. × 10 diameters.

coma, and has grown into the ducts of the gland as papillary projections. These are covered by the lining epithelium, which they push ahead of them in their growth, and which increases in consequence; but this is only secondary, and these tumors should be considered as connective-tissue formations.

A diffuse enlargement of the breast due to uniform increase in the glandular elements has occasionally been described under the name of diffuse adenoma. This condition is bilateral, usually occurs about the time of puberty, and, strictly speaking, is a hyperplasia and not a new growth.

The *true adenoma* is unilateral, definitely circumscribed, and encapsulated. It usually occurs in young women, starting as small nodes in the upper or outer quadrant of the gland. It becomes round or oval in shape and sometimes grows to considerable size, though usually small. On section it is uniformly smooth, grayish white, and quite firm, though occasionally it is soft and slightly nodular.

Histologically, it may be composed of acini or of ducts lined by cylindrical epithelium. The stroma is fibrous and varies greatly in character and amount, but is looser and more cellular than that of the normal gland. According to the character of the interglandular tissue, it may be an adeno-fibroma, adeno-myxoma, adeno-sarcoma, etc.

Adeno-carcinoma is generally considered to be an unusual form of breast tumor. Halsted (1898), however, reports five occurring in a series of one hundred and fifty breast cancers. According to Halsted's observations, these growths differ from ordinary cancer of the breast in that they are softer, more pedunculated, and discharge a peculiar serous fluid when ulcerated. Histologically, they are composed of very large tubes lined by epithelium many layers deep. In three of Halsted's cases the growth was pure adenoma (malignant adenoma); in the others carcinomatous areas were present. Metastases in the axillary lymph nodes were found in none.

Ovary.—The multilocular cystadenoma is the commonest tumor of the ovary, and the one usually attaining the greatest size. It may be small or it may weigh a hundred pounds or more. It is a benign tumor and never produces metastases. The surface may have no epithelium, or it may have a single layer of flat epithelial cells. The numerous cysts of varying size which make up the mass are lined on their inner surface by a single layer of cylindrical cells, often ciliated. The nuclei are oval and

FIG. 41. Papillary Adeno-Cystoma of Ovary. More strongly magnified than Fig. 40, in order to show cyst wall; papillary ingrowths of connective tissue; epithelium lining papillary projections. As seen in cross section this epithelial structure gives the appearance of a glandular growth.

placed near the basement membrane. Some of the cells may be swollen and filled with clear contents, giving them the appearance of goblet cells. The contained fluid is thick, viscid, sometimes jelly-like, and may be colorless, or, if there has been hemorrhage, yellowish or reddish brown. This fluid is formed by secretion from the epithelial cells, by the transudation of serum from the blood-vessels, and by the degeneration of the epithelial cells. The most important chemical substance in the fluid is pseudomucin, a true secretion of the newly formed epithelial cells. It does not occur in the normal ovary, in dropsical Graafian follicles, or in the parovarium.

Calcification or necrosis of the cyst wall may occur as secondary changes. Both are unusual.

The *papilliferous adeno-cystoma* is characterized by an ingrowth into the cyst of a papilliferous connective tissue covered with epithelium. On cross section the appearance is that of gland tubules. The papillary growths may be prominent, or they may appear simply as flat excrescences on the surface of the cysts. The epithelium is similar in character to that in the multilocular adeno-cystomata. This tumor is not malignant in the ordinary sense; but after rupture of the cysts a local growth on the neighboring peritoneum may occur.

These growths are supposed to originate from the epithelium of mature or residual embryonic follicles or from the germinal epithelium of the ovary. Pflüger has pointed out the glandular structure of the ovary, and Spiegelberg and Langhans have shown in the ovary, even after birth, residues of its embryonic glandular structure. Doran, as a result of his investigations, believed that the tumor might originate in childhood or even in the intrauterine period. Williams states that the papillary adeno-cystomata originate from the epithelium on the surface of the ovary or from that of the Graafian follicles, or from both.

Adeno-carcinoma of the ovary may originate in the ovary, may develop in a papilliferous adeno-cystoma, or may be secondary to a similar growth in the uterus.

Thyroid.—Aside from the hyperplastic changes associated with the condition known as goitre, circumscribed adenomatous tumors of the thyroid occur. These appear as soft nodular growths composed of glandular tubules lined by tall cylindrical epithelium. Within these tubules papillary growths sometimes appear (adenoma papilliferum). Within the tubules is seen the colloid material characteristic of the normal thyroid. Although this tumor is one of the purest types of adenoma, it may produce metastases. It may also by direct extension invade the structure of the larynx.

Testicle.—The form of tumor as it occurs in the testicle is generally known as cystadenoma. It may occur in the child or in the adult. It is attributed by some writers to error in development. Two forms are recognized. In one the tubules are lined by cylindrical cells which sometimes have cilia, their contents being a clear or blood-tinged slimy fluid; in the other the epithelium is stratified and the contents a greasy substance with many fatty epithelial cells. The growth usually starts in the testicle and may attain a large size. Instances of carcinomatous changes have been reported.

Prostate.—The tumor usually occurs in this organ as an adeno-carcinoma and is rare. It appears as soft, nodular masses which project into the urethra or neck of the bladder and invade surrounding tissues. Ulceration is frequent, and when it occurs is accompanied by copious hemorrhage.

Pituitary Body.—Adenomata of this structure are rare, but are occasionally reported in connection with cases of acromegaly. They may be as large as a pigeon's or hen's egg; may protrude from the sella turcica, press on the brain, and extend even into the ventricles. Histologically, they are made up of large, tortuous, sometimes branching tubes lined by epithelial cells.

Pancreas.—Adenomata of this gland are not common. They are generally of the racemose type. Cesaris-Demel (1895) reports a distinctly encapsulated adenoma the size of a dove's egg in an atrophied pancreas. The cells were irregular and primitive, occurring in one and sometimes in several layers, generally arranged in alveoli.

Lachrymal Gland.—Adenomata of this gland are not very common. They generally occur in persons of advanced age. By pressure they may interfere seriously with the movements of the eye. They do not tend to become malignant and are only troublesome on account of their size. Adeno-carcinoma has been reported, but is very rare.

Pineal Gland.—The occurrence of adenomata of this body is occasionally referred to in the literature.

Richard Mills Pearce.

ADENOMA OF THE SKIN.—Adenomatous proliferation of the cutaneous glands is an extremely rare occurrence, and it is only within a comparatively recent period that the condition has been recognized. Hypertrophy of the skin glands, on the other hand, is a concomitant of many chronic local disturbances of nutrition, and doubtless in some of the cases recorded as adenoma there has been confusion between this condition and hypertrophy. The considerations involved in the differentiation of hypertrophy and adenoma have been discussed in the preceding article.

Adenomata of the skin naturally fall into two classes: adenoma of the sebaceous glands (*adenoma sebaceum*), and adenoma of the sudoriparous glands (*adenoma sudoriparum*).

ADENOMA SEBACEUM.—(Synonyms: *Végétation vasculaire* [Rayer]; *Nævi vasculaires et papillaires* [Vidal]; Adenoma of the sebaceous glands; Steatadenoma; German, *Talgdrüsenadenom;* French, *Adénome sébacé.*)

The earliest recorded cases of the disease are found in the writings of Rayer and of Addison and Gull, who, however, failed to interpret correctly the anatomical condition, which Balzer was the first to recognize, though Balzer's case, curiously enough, has been shown by later investigators to be one of acanthoma adenoides cysticum. Cases have since been described by Hallopeau and Vidal in France, Mackenzie, Pringle, Jamieson, and Crocker in England, and Caspary and Boeck in Germany. The only case recorded in America has been described by the present writer.

The disease manifests itself in the form of small multiple benign tumors, which may be distributed generally on the face, but occur most frequently at the sides of the nose. Their distribution is usually fairly symmetrical, but in Jamieson's and one of Crocker's cases they were limited to one side of the face, and in my own case the lesion was in the form of a linear patch on the forehead. The lesions in some cases were present at birth or appeared in infancy; but a more active growth, as to number and size of the tumors, has been noted at the time of puberty. In Caspary's case and in my own they did not appear until the seventeenth and the nineteenth year respectively. The individual growths seldom undergo any change after they have attained their development, though involution of a few of the nodules with resulting faint cicatrices has been noted.

The little tumors vary in size from 1 to 5 mm., are usually round and convex in shape, and the epidermis over them may be smooth or have a rough and somewhat warty appearance. Their color may be that of the normal skin, or they may have a brownish or even bright red hue. The color depends greatly on the presence or absence of telangiectases, which often appear as fine lines ramifying over their surface, and in some cases may form so striking a part of the tumor as to give the whole the appearance of a vascular nævus. In Vidal's case and in mine there was cystic degeneration of a part of the tumors, giving the appearance of small yellow nodules from which on incision a drop of inspissated sebaceous matter could be squeezed. Some importance has been attached to the fact that in many of the cases there were other striking abnormalities of the skin: warts, pigmented and hairy nævi, and small pendulous fibromata indicating a congenital tendency to malformations of the skin. It is probably only a coincidence that

many of the cases have occured in persons of deficient intelligence, some of them epileptics.

Anatomy.—Under the microscope the entire tumor is seen to be composed of larger and smaller masses, which bear the closest resemblance to the acini of normal sebaceous glands. It is indeed only in the great number, extent, and complex arrangement of the lobules that an abnormal condition becomes apparent. In some cases solid epithelial buds are given off from existing sebaceous gland acini, and the cells of these buds later undergo the peculiar fatty changes indicative of the glands from which they take their origin. Unna, who draws a very sharp distinction between hypertrophy and adenoma of the sebaceous glands, regards all the published cases with one exception as examples of hypertrophy.

The *treatment* of the condition is indicated only for cosmetic purposes. When the lesions are few in number they may be removed by excision, by scarification, or by electrolysis. When they are very numerous, any form of operative interference is inadvisable.

ADENOMA SUDORIPARUM.—(Synonyms: Adenoma of the sweat glands; Spiradenoma; Syringadenoma; German, *Schweissdrüsenadenom;* French, *Adénome sudoripare.*)

The disease which has been described under the various names of hydradénomes éruptifs, syringocystadenoma, epithelioma or acanthoma adenoides cysticum, etc., and which was formerly regarded as an adenoma of the sweat glands, is now known to have no connection with these structures. The reader is referred to the article on *Epithelioma of the Skin* for an account of this condition.

In view of the fact that the sweat gland is an approximately uniform cylindrical tube, the distinction between hypertrophy and adenoma of these glands can readily be made. Any deviation from the typical structure in the form of lateral budding or outgrowth suffices to constitute adenoma, providing, of course, that the new formation does not break through the membrana propria of the gland. From this point of view adenoma of the sweat glands is by no means a rare occurrence. It is frequently found in connection with other diseases of the skin, especially in association with tumors and malformations of the blood-vessels of the cutis and hypoderm, and with cancers of the skin. Under these circumstances, however, the adenoma contitutes merely an interesting microscopical condition without giving rise to any clinical symptoms. In these cases the adenomatous formation affects only the coiled portion of the gland, and it is a noteworthy fact that in all the observations hitherto recorded there has been a sharp distinction between adenoma of the coil and adenoma of the duct. This distinction has given rise to the terms spiradenoma and syringadenoma. Adenomata of the sweat glands occurring independently are of extremely rare occurrence.

Unna in his "Histopathology" was able to cull only six cases of *spiradenoma* from the literature, to which he added a seventh. The tumors varied in size in the different cases from a small chestnut to a hen's egg; were found on the head, neck, or extremities in middle-aged or elderly people (one case in a child); and presented no characteristic clinical features. The diagnosis can be made only with the microscope. The proliferation occurs in the form of solid epithelial buds, which usually show a tendency to grow in curved lines as they increase in length, and to become canalled like the structures from which they took their origin.

Of the *syringadenomata* there is but a single undoubted case on record, that of Petersen. It was in the form of a papillary *nævus unius lateris* on the neck, trunk, and thigh of a girl of twenty. The adenomatous proliferation was confined strictly to the ducts of the glands, which appeared considerably widened shortly above the coil, the cubical epithelium became cylindrical, and outgrowths developed which were sometimes solid and sometimes canalled. These outgrowths divided repeatedly like the branches of a tree, and produced thus the semispherical or mushroom form of the tumors. The new-formed tubes were lined with a distinct membrane and showed no signs of colloid degeneration.

Sigmund Pollitzer.

ADIPOCERE.—(*Adeps*, fat, and *cera*, wax. French, *adipocere, gras des cadavres;* German, *Fettwachs, Adipocire.*) As the name suggests, adipocere is a material resembling in its gross appearances fat and wax. It is a semitranslucent, white, or slightly yellowish substance of about the consistency of cheese at ordinary temperatures; has a greasy feel, and yields slightly when pressed between the fingers. If a piece be rolled between the fingers for a few minutes it becomes much softer. When rubbed with water it forms a lather. Its composition is that of a soap, being made up of the calcium soaps of palmitic and stearic acids and also of acid ammonium soaps. Examined under the microscope it shows, occasionally, very numerous scales having a crystalline form; more commonly nothing but fat globules are to be seen. If it be melted and again allowed to cool, it is found, often, to have crystallized in round masses made up of needle-shaped crystals, radially arranged; hence like stearin.

Most of the specimens of adipocere with which one is familiar come from the macerating troughs of anatomical departments and from museum jars which have long contained specimens immersed in dilute alcohol. It thus represents the results of a metamorphosis of dead animal tissues placed under peculiar circumstances.

The only special point of interest in connection with adipocere lies in the fact that it is occasionally found in dead bodies which have been buried a considerable time. In fact, nearly all the structures of the body, except the bones, have been found converted into this material. For centuries its presence had been noted in disinterred corpses, but no opportunity was afforded for studying it on a large scale until 1876, when, upon the removal of the bodies from one of the cemeteries in Paris, a considerable proportion of those buried in the common grave were found by Foucroy to have been converted, to a greater or less degree, into this peculiar, fatty, wax-like material, and to it he gave the name by which it has since been known.

The conditions favoring its formation in buried corpses are still unknown. Doubtless moisture is always necessary; but why, of six or eight bodies buried in close proximity, and hence presumably under like conditions of soil and moisture, one should undergo almost complete change into adipocere, while the others undergo ordinary putrefaction, as has been observed, is at present inexplicable.

At one time it was thought that adipocere might be of medico-legal importance in helping to determine the length of time a corpse had been buried. Foucroy believed that thirty years was required for its formation. Later, this was reduced to one year; and Caspar mentions finding adipocere in the body of a new-born child which had lain for three months in a house cesspool. It is therefore impossible to establish an idea, from the presence of adipocere in a corpse, as to the length of time it has been buried.

Artificially, adipocere can readily be produced, either by soaking muscle in dilute nitric acid for two or three days and then washing it thoroughly in warm water, or by allowing the muscle to soak for months in a trough supplied with running water.

Adipocere is probably closely allied to cholesterin.

W. W. Gannett.

ADIPOSIS DOLOROSA.—At a meeting of the American Neurological Association, held in New York in June, 1892, the writer presented the histories and photographs of three cases of an affection which up to that time had not been recognized. The first of these cases had been under the writer's care since 1887, and recently she has died. The second and third were discovered in the wards of the Philadelphia Hospital in 1891. These cases also died, and, including the first, came to autopsy.

The histories of these cases are briefly as follows:

CASE I.—M. G——, aged fifty-one, female, widow, a native of Ireland, and a domestic. Her father had died at forty-five of erysipelas. Her mother, who had had

FIG. 42.—Author's First Case, Showing Large Masses of Fat on Back and Upper Arm.

eighteen children, died at forty of some affection incident to the menopause. Of her brothers and sisters, seven died in childhood, one in adult life of pleurisy, one sister in childbirth, a brother and two sisters of phthisis, while the remaining five are living and apparently in good health. None of the patient's relatives have ever suffered, so far as she knew, from symptoms similar to her own, nor had any of them ever had any nervous or mental affection.

As a child she had had measles, whooping-cough, and scarlet fever. Menstruation began normally at fifteen. At eighteen she married. Some years later she had an attack of pneumonia, but made a good recovery. She

FIG. 43.—Another View of Author's First Case.

had in all seven children and one miscarriage. Five children died in early childhood: one from cholera infantum, two from measles, one from "congestion of the brain," and the fifth from spasms. The menopause set in abruptly at thirty-five. From this time up to within two or three years her health had continued good. She had undergone some increase in weight, but beyond this nothing worthy of mention could be elicited. Syphilis was denied, as was also alcoholic excess. However, the condition of the patient on several occasions, upon her return to the hospital after furlough, was such as to throw more than doubt upon her denial of alcoholic abuse.

When forty-eight or forty-nine years of age she noticed that her arms were becoming very large. The upper arms and shoulders appeared swollen. The swelling continued steadily to increase, and was for about a year unattended by any other symptom.

In November, 1886, she was admitted to the surgical wards of the Philadelphia Hospital for the rupture of a varicose vein of the leg. In the following February she was transferred to the medical wards for a severe attack of bronchitis. Later she had an attack of severe pain and swelling in the right knee, attended by chill and fever. She was treated for rheumatism and obtained prompt relief. Two weeks after this she complained of a sharp darting pain in the right arm. It began on the outer aspect above the elbow and gradually increased in severity and extent, spreading upward to the shoulder and neck, and downward to the forearm and hand. It was shooting and burning in character. She felt at times as though hot water were being poured upon the arm, and again as though the hands and fingers were being torn apart. No rise in temperature was noted. The pain was often paroxysmal, but it was never absent. On June 4, 1887, she was transferred to the nervous wards of the hospital and came under the care of the writer.

Her appearance at this time was striking. She was a tall, large-framed woman who looked as though she had at one time presented a fine physical development, but she seemed unnaturally broad across the back and shoulders. On removing the clothing an enormous enlargement of these parts was disclosed. The enlargement affected both shoulders, the arms, the back, and the sides of the chest. It was most marked in the upper arms and back, forming here huge and somewhat pendulous masses. It was elastic and yet comparatively firm to the touch, and it was impossible to produce pitting. In some situations it felt as though finely lobulated, and

in others, especially on the insides of the arms, as though the flesh were filled with bundles of worms. The skin was not thickened; it did not take part in the swelling, and it was not adherent to the subjacent tissues.

In addition the swelling was very painful to pressure. Pronounced pressure appeared to be absolutely unbearable. The nerve trunks also were exquisitely sensitive, but this painful condition was not by any means limited to them, but permeated the swollen tissue as a whole.

The muscles were not involved in the swelling. The affected parts were, however, quite weak. Examined electrically the muscles of the shoulders and arms yielded a negative result, partly because of the great resistance caused by the intervening tissue. Slight qualitative and quantitative changes were noted in the muscles of the forearms, while in the hands distinct reaction of degeneration was noted in the thenar and hypothenar groups, more evident on the right side.

Cutaneous sensibility was much diminished. On the right arm various areas existed in which no response whatever was given to the æsthesiometer. They were large and irregular in shape, and very sharply defined, and were present on both the inner and outer aspects. In the finger tips the points could not be at all separated. In the left arm, some impairment of sensation was detected on the outer aspect of the forearm, and in the finger tips sensation was decidedly below normal. Sensibility to heat and cold appeared also to have been lessened.

An examination of the legs showed that cutaneous sensibility was distinctly lessened on the right, while little or no impairment was discoverable on the left. There was no alteration of the gait, but both knee-jerks were lost. She complained of a "velvety feel" in the soles of both feet and also in the tips of the fingers.

No enlargement was noted at this time in any part of the body save in the arms and shoulders. The face was pale, as were also the mucous membranes. There was, however, a little color in the cheeks, more noticeable at times. Her features were well formed and intelligent. Her hair was dark and fine. Her mind was unimpaired, except that at times she was much abstracted. Sometimes she gave conflicting answers to questions, so that the latter had often to be repeated.

Ten days after her admission to the nervous wards she had a chill, followed by fever and a painful herpetic eruption over the upper portion of the left arm and anterior portion of the left side of the chest. Some five or six days later another crop of vesicles made its appearance on the back and on the front of the chest.

Nothing further worthy of note occurred until October 13th, when the patient had another severe attack of bronchitis, which was accompanied by much dyspnœa.

In the latter part of the following December it was noted that during one of her paroxysms of pain the swelling of the right arm became more decidedly lobulated. The arm became more sensitive than ever, and on examination hard, cake-like masses were felt, resembling, as the resident physician expressed it, the caking of milk in a breast. This caking or more pronounced lobulation was afterward repeatedly noticed during paroxysms of pain. At this time also she suffered from an attack of pain in the right knee, and in the popliteal space a diffuse swelling was felt which exhibited the same nodulated feel as did the swelling elsewhere. It was also very painful.

At various times subsequently paroxysms recurred, during one of which swelling was noticed in the posterior triangles of the neck. The latter seemed later to be permanently fuller than normal. Bronchitis also recurred, accompanied by dyspnœa, and at one time by free expectoration of bloody mucus.

In the following April she experienced an attack of pain of unusual severity. The latter, which involved the right arm and shoulder, right side of trunk and back of neck, now for the first time spread to the face and head. The right side of the face became distinctly swollen, and presented to the touch the same nodulated feel so characteristic of the swelling in other portions. At the same time the tongue and pharyngeal tissues appeared to become swollen. Her tongue, she said, felt much too large for her mouth. In addition her voice was very hoarse, and she spoke with great difficulty. This condition persisted for upward of a week, and then slowly subsided. For some time subsequently, she spat blood, the source of which was not determined, though it appeared to come from the throat. The reddish color in the cheeks also became more pronounced, until it covered the entire forehead like an intense blush. This blush was afterward observed to occur with other paroxysms of pain.

During the summer of 1888 the patient's condition underwent some change. The paroxysms became less frequent and less severe. Hand-in-hand with this improvement, sweating became much more marked. However, paroxysms occurred from time to time, and upon one occasion a thick welt-like swelling, exquisitely painful, was observed extending from the upper and inner angle of the scapula, perpendicularly down the back to very nearly the lumbar region. Upon another occasion swelling again made its appearance in the right popliteal space, as well as on the inner aspect of the knee. In the latter locality the swelling became permanent, and the tissues presented the same peculiarities as noted elsewhere. Pain also occasionally appeared in the left arm. Prolonged attacks of cardiac dyspnœa occurred every week or two, and apparently independently of bronchitis.

An examination of the eyes by Dr. de Schweinitz revealed contraction of the fields of vision for form and colors, most marked in the left eye. The other special senses, hearing, taste, and smell, appeared to be somewhat obtunded. An analysis of the urine yielded a negative result. A blood count failed to reveal an increase of white blood corpuscles.

Upon a number of occasions the patient during paroxysms of pain vomited blood; upon several occasions this was observed by the writer himself. The quantity could not be accurately estimated, but while it was never large at a single emesis it was constantly brought up in repeated vomiting during an entire night or day.

Measurements were made of this patient at various times, and these have shown a steady increase in the bulk of the enlarged parts.

Of late the patient has not suffered as intense pain as formerly. Cardiac dyspnœa, however, is a frequent and distressing symptom. The face is still flushed. Recently, shooting pains have appeared in the abdominal region, and examination discloses in this region an extensive deposit of tissue to which the pain is referred. A large longitudinal wheal, especially sensitive, is found in the left lumbar region.

Swelling has also made its appearance over the left hip, and to some extent over the right. The thighs and buttocks do not seem enlarged in proportion, but soft masses are now found on the inner sides of both knees, the right being larger than the left and more painful to pressure. A small nodule to the right of the scrobiculus is especially painful.*

CASE II.—E. W——, female, aged sixty-four, married, a native of England. Her father had died of alcoholism at middle life; her mother of œdema of the brain (verified post mortem). An elder brother and sister and one younger brother are still living. The younger brother, when a child, was peculiar; he would run to people in a fright and say that he was drowning, and the like. He is now in average health, but drinks heavily. He has a contracture of the ring finger; has nine children, all of whom

* While this article was passing through the press, Case I. came to autopsy and a microscopical examination of the tissues was made. The results can be briefly summarized as follows: Marked degeneration of the postero-median columns of the cord, degeneration with proliferation of the connective tissue of the peripheral nerves, and also striking abnormalities in the thyroid gland. The gland, which was somewhat below normal in size, presented acini very irregular in shape, many of them greatly distended with retained colloid material. In other situations there were numerous small acini with marked proliferation of cells, the appearance being that of a hypertrophy of glandular tissue. The results will shortly be published in detail.

FIG. 44.—Author's Second Case.

appear to be well. The older brother suffers periodically from violent headache; also, since a young man, he has suffered from constantly cold feet, this being so severe as to disturb sleep and cause great distress. He has had five sons and two daughters. One son died of tetanus (traumatic); the others are well. One daughter has a contracted middle finger of the right hand; has never suffered pain in the finger. Patient's sister is living, sixty-five years old; she has no children.

The patient herself does not remember having had the ordinary diseases of childhood. In early infancy she had convulsions, which recurred with great frequency for a time. On her being relieved of lumbricoid worms, however, the convulsions ceased.

At seventeen she was married. She had two sons, the older of whom is now forty, and who has seven healthy children. The younger son died, at two years of age, of hemorrhagic diarrhœa. The patient had no miscarriages and no still-births. She left her husband because of venereal disease which he had contracted. She was told by a doctor that she had escaped infection. A year later, however, she had sore throat, with white patches. For many years she was an immoderate drinker. For weeks at a time she was intoxicated every night.

Menstruation began at eleven and ceased abruptly at thirty-five. She lost habitually an unusual quantity of blood, but never suffered any discomfort.

Her present malady began about fifteen years ago, when she was forty-nine years old. At that time she was living in California. The first thing noticed was a constant feeling of coldness about the knees, followed by swelling, which gradually increased. At first she thought that the swelling was due to her growing fat, but later she was astonished to see that there was a localized mass on the inner aspect of each knee. At the time there was dull aching pain in the affected parts. Later, the right arm became involved, a mass making its appearance on the outer aspect. Her body, as she then observed, had also become larger, as her stays were too small for her. During this time, while still in California, inability to perspire freely, except at the Turkish bath, was marked, and was part of her reason for coming East. Since she has been in Philadelphia the lack of perspiration has not been as marked as before. Various plans of treatment were tried, but did not influence the progress of the disease, *i.e.*, the growth of the swelling. Five or six years ago, injections of chloroform were made into the swellings on the inner sides of the knees, but no good was accomplished. Painful ulcerations were the result, and scars of considerable size mark their location.

About five years ago a slight swelling appeared in the epigastrium. This gradually increased in size until it resembled the breasts in shape, and afterwards spread so as to involve nearly the whole abdomen.

From the knees the process extended to the thighs, and gave rise to large masses on their outer side and about the hips.

At various times she had suffered with pains apparently situated in the enlarged tissues, or running down the limbs. Sometimes these attacks were fairly well localized in one limb, in one side, or about a joint.

Five years ago her attention was called to a peculiar condition of the right hand. The last phalanx of the second finger began to be fixed in a flexed position, while the end of the finger appeared to be growing somewhat smaller. Later, the remaining fingers of this hand became involved, and all the phalanges deformed. The deformity, as seen now, consists of flexion of the first phalanx, of marked overextension of the second, and of half-flexion of the third. The thumb is also stiff, but all of its joints are flexed. For some time past she has

FIG. 45.—Rear View of Author's Second Case.

noticed that the thumb of the left hand was growing to be like that of the right.

A year ago the patient had a quasi-rheumatic attack affecting the deformed hand and the arm. The pains seemed to run up and down in the arm rather than about the joints. Some months ago she had pneumonia of the right lung, and made a good recovery.

For several months past she has had slight uterine hemorrhages at times, associated with which were dull, aching pains, resembling those formerly felt before menstruation.

In addition, she stated that the swelling had spread up from the knees over the thighs unequally; that the left thigh and buttock had been earlier and more conspicuously enlarged than the corresponding parts on the right side. Gradually, however, the latter became enlarged to an almost equal degree. Later, swelling appeared over the left arm, and later still on the back and sides of the trunk, and, wherever appearing, it gradually became diffuse and finally reached very great proportions. The patient further volunteered the statement that she had formerly been very slight in build.

To ordinary observation she merely presented the appearance of an excessively obese person. However, examination soon revealed that the enlarged tissue was very unevenly distributed. In the region of the knees, where it had first made its appearance, it was excessively irregular and lumpy. To the touch it resembled in a remarkable degree the swollen tissues of Case I. It gave the same nodular feel, and could not be made to pit on pressure. At the time of the examination no tenderness existed in the swellings, but shooting pains were referred to them in various situations. This was particularly the case in the mass over the right hypochondrium. In addition, she complained of scalding sensations on the inside of the right cheek and on the right side of the tongue. Nothing abnormal could be discovered in the mucous membrane of these parts. No tenderness could be discovered in any of the nerve trunks at the time of the examination. The patient was excessively weak, and could move about her bed or sit up only with great difficulty. Her grip was almost *nil*. No tendon jerks could be elicited, probably because of purely mechanical difficulties. For the same reason an electrical examination could not be made.

Slight diminution of tactile sensibility and of the temperature sense, and also some analgesia, were present. An area of absolute anæsthesia existed on the back of the left arm, extending thence over the posterior aspect of the left shoulder. A marked increase in the swelling had taken place during the last year, measurements showing, for instance, that the left forearm had increased one inch and seven-eighths, and the right forearm one inch and three-eighths; the left arm one and a half, and the right arm two inches. This increase appeared to be maintained throughout.

Subjectively the patient complained much of headache. Her face was very much flushed, and she suffered greatly from cardiac dyspnœa. It was a persistent and distressing symptom. Examination of the eyes proved negative, as did also that of the urine. Perspiration, according to the patient's statement, was scant. Face was not involved in the enlargement; no subnormal temperature; hair thin, but not excessively so; no difficulty in speech; no mental impairment.

The patient remained very much in the same condition for some two weeks following her admission to the nervous wards, when her dyspnœa greatly increased. Her pulse, already soft and compressible, became irregular and intermittent. This condition, though relieved from time to time, persisted until hands and feet became puffy, the face cyanotic, and the lungs œdematous and congested. Death occurred on December 22, 1891.

Autopsy, December 23d.—Body that of a very large woman. Weight estimated at about three hundred pounds. Face dark from venous congestion. Some discoloration on under surface of body and thighs. A number of large white scars on either side over the knees. Legs and feet œdematous. Body distorted and flattened, as though by its own weight.

Scalp and calvarium revealed nothing abnormal. Veins of dura and longitudinal sinus full. Venous congestion of the pia. Cortex a little darker than normal. Puncta vasculosa prominent. Brain otherwise normal. Spinal cord appeared normal. Skin of thorax appeared normal. The subcutaneous tissue was fatty and moist.

Thyroid gland small, indurated, and infiltrated by calcareous matter in both lobes.

Right lung œdematous and tightly adherent to chest wall. Left lung œdematous, with hypostatic congestion posteriorly. Both pleural cavities contained a large excess of fluid.

Pericardium contained some six or eight ounces of fluid, in which was suspended some flocculent lymph. Weight of heart, twenty-seven ounces; the right side dilated, the moderator band much thickened; walls of left side also much thickened; marked hypertrophy of the columnæ carneæ and papillary muscles; some fatty change, especially in the walls of the right ventricle.

Over the abdomen the subcutaneous fatty tissue was three inches thick. About a pint of ascitic fluid in abdomen. Stomach much dilated. Intestines normal. Liver showed some fatty infiltration; otherwise normal. Spleen apparently normal, though somewhat dark. Kidneys both revealed, aside from slight adhesions of the capsules, nothing specially abnormal.

In the pelvis an ovarian cyst, containing some six ounces, and a hydrosalpinx were found on the left side. Uterus seemed a trifle larger than normal. Bladder normal.

Brain, cord, some of the nerve trunks, pieces of skin and subcutaneous tissue, pieces of the liver, kidneys and spleen, a fragment of muscle, and the whole of the thyroid gland, were removed for microscopic examination. The specimens were left in the care of Dr. H. W. Cattell, assistant to the pathologist of the hospital. Unfortunately, Dr. Cattell fell ill with scarlet fever, and during his absence the specimens, together with those of Case III., were thrown away by an attendant.

Case III.—M. M——, aged sixty years, widow, a tailoress by occupation, and a native of Germany, but a resident of America for twenty-six years, was admitted to the nervous wards of the Philadelphia Hospital, October 7, 1891. Memory very poor. History obtained in part from relatives.

Her father and mother healthy, though her mother died of heart disease. She had seven brothers and sisters, all apparently well. She had no children; had never been pregnant.

Many years ago a lump appeared at the back of the neck, for which she consulted Dr. Gross at the Jefferson Medical College, but for some reason no operation was performed. At various times thereafter swellings made their appearance in various situations. Further, she lost more blood at her menstrual periods than normal. Occasionally she suffered from hæmatemesis and epistaxis. The climacteric occurred at forty-six. No history of any intercurrent affections. Mental impairment had been noticed for about two years.

On examination the patient was found to be excessively feeble. For some two weeks she had been unable to walk. She lay, for the most part, in a quiet, apathetic state, though when aroused she answered questions slowly, but intelligently. She was also somewhat deaf.

Examination further revealed soft, fat-like masses or swellings in various situations. Thus, a large, soft mass was found over either biceps, and others, somewhat smaller, over the outer and posterior aspect of either upper arm. Two large masses were found over the belly, separated above the umbilicus by a deep, transverse crease. Another gave excessive prominence to the mons Veneris. From the back of the neck, at its lower part, sprang a big mass like a hump, while a diffuse swelling gave a cushion-like coating to either half of the back, and extensive deposits gave unnatural prominence to either hip. In marked contrast, the deposit was

absent from the forearms and hands, from the face, from the thighs and legs, and from the buttocks. The gluteal regions, in fact, seemed flattened and sloping.

The deposit over the back seemed tolerably firm and resistant; over other portions it was quite soft, though

FIG. 46.—Author's Third Case.

elastic, and exhibited the same nodular feel noted in the previous cases. Further, it was discovered at once that these masses were painful to the touch, the patient complaining very much when only moderate pressure was exercised. This was especially true of the deposits over the arms and back of the neck. In addition, the patient complained of stabbing pains in the deposits, more marked in the regions just mentioned. There was no tenderness over the nerve trunks. She complained also of headache.

When the examination was made it was also further noted that the left radius was rough and nodular for about two and a half inches in its middle third; also, that there was a large discolored area on the outer aspect of the left forearm resembling a syphilitic scar. Both tibiæ were somewhat nodular, though no scars were discovered on the legs. A few white scars were seen on the forehead. Finally, quite a number of purpuric spots were observed on the forearms, thighs, legs, and back.

The skin of the forearms and hands, as well as that of the legs and feet to a less extent, was dry, dark, and much roughened.

Cutaneous sensibility was found to be generally diminished, while a few patches of anæsthesia were noted. One of these was an area diffused over the right side of the trunk and the right shoulder. These areas of anæsthesia appeared to be constant, and were confirmed at various examinations.

Owing to the extreme weakness of the patient, the study of the eyes could not be made satisfactorily, but, so far as it went, it was negative. The urine contained albumin, though no casts were found.

In answer to questions the patient said that she had not been sweating freely for years, but owing to her mental condition no importance was given to this statement. She at no time presented any change in temperature. Her hair was well preserved.

The patient seemed to fail slowly and steadily, although liberal diet and stimulants were freely used. Her dementia gradually deepened, and for some days before death she voided urine and fæces involuntarily. She finally died in a comatose state on November 5, 1891.

Autopsy, November 6th.—Body that of a large woman with irregularly distributed fat-like masses. Some discolorations on the back. Small bed-sores beginning on the buttocks.

Scalp and calvarium normal. Dura normal. Pia very œdematous. Brain very soft and œdematous. Cord revealed nothing abnormal.

On incising the skin of the chest and abdomen it was found to be normal in appearance, but the subcutaneous tissue, which looked like very white fat, was excessively thick, attaining below the umbilicus a depth of seven inches.

The thyroid gland was larger than normal, harder to the feel, and much calcified, especially the right lobe.

The heart weighed eight and a half ounces. Both aortic and mitral valves were slightly thickened. Heart substance evidently fatty. Lungs emphysematous.

The mucous membrane of the stomach revealed a chronic gastritis. The liver weighed forty-four ounces, and, beyond some fatty infiltration, was practically normal. Spleen normal. The kidneys, however, showed decided shrinking and loss of cortical substance, with somewhat adherent capsules. Nothing noteworthy was seen in the pelvic organs.

FIG. 47.—Rear View of Author's Third Case.

As in Case II., brain, cord, nerve trunks, skin and subcutaneous tissue, thyroid gland, and portions of other viscera were removed for microscopic examination, but, as already mentioned, the specimens were subsequently lost.

It was not without some hesitation that these cases were presented together. The writer was well aware that without a microscopic examination to supplement

the autopsies their study was incomplete, and yet the cases are in themselves so interesting, and appear to be so unusual, that their publication in a group, with such data as are at hand, seemed to him to be more than warranted. Case I. had originally been published in the *University Medical Magazine* for December, 1888, under the title, "A Subcutaneous Connective-Tissue Dystrophy of the Arms and Back, Associated with Symptoms Resembling Myxœdema." Case II. had been discovered in the medical wards of the Philadelphia Hospital by Dr. Frederick P. Henry, in 1890, and was published by him in the *Journal of Nervous and Mental Diseases* for March, 1891, as a "Case of Myxœdematoid Dystrophy." Dr. Henry fully recognized the relation existing between this case and that previously described by the writer, and he adopted the term dystrophy in order to bring the cases "into the same category." In November, 1891, this case (Case II.) having been transferred to the nervous wards of the Philadelphia Hospital, came under the care of the writer and was studied again. The account here given is abstracted partly from the notes of Dr. Henry, and partly from those of the writer.

Case III. was discovered in the nervous wards in October, 1891.

Certainly these cases differ radically from ordinary cases of lipomatosis, and certainly the nervous symptoms present must have a special significance. To begin, the enlarged tissue makes its appearance in a very irregular way. Nodules of soft tissue are at first deposited in some one situation, or perhaps in corresponding places in both arms or in both legs. For a time the deposit is limited to these original areas, but subsequently it makes its appearance elsewhere, and may become very extensive. Regions, however, may exist which remain permanently uninvaded. In Case I. the enlargement was first noticed in both upper arms, and later in the back. Subsequently a swelling made its appearance on the inner aspect of the right knee, to be followed months after by a similar swelling in a corresponding position over the left knee. Later still, swellings made their appearance in various other situations. However, the legs, with the exception of the knees, have remained free from involvement, while the thighs and buttocks have only recently shown a doubtful change. In Case II. the enlargement began on the inner aspect of either knee, and then gradually spread unequally over the thighs and buttocks. Later, the left arm became involved; next, the sides and back, and, finally, the entire trunk. In Case III. the enlargement began in the back of the neck, and then at various times appeared in other situations. It remained absent from the face, the forearms, the legs, the thighs, and the buttocks. It is a peculiarity of this case, also, that the enlargement tended to produce distinct segregated masses.

Not only is the development of the enlargement irregular and even capricious in these cases, but there is, in addition, another important fact to be remembered, and that is: that at some time or other the enlargement is accompanied by pain or other nervous symptom. Thus in Case II. pain, shooting in character, and a sensation of coldness preceded the appearance of the nodules on the insides of the knees. In Case I. shooting and burning pains made their appearance about a year after the swelling had appeared in the arms, while similar pains, very great in intensity, preceded the appearance of the swelling on the inner aspect of the right knee and in other situations. Case I., it should be remembered, was observed by the writer for a number of years, and was therefore studied in great detail, and pain was noted as a marked feature of the case, especially in the early course of the disease. Occasionally it was observed in old areas of enlargement, and again in regions free from the swelling, but in which the latter subsequently appeared. In Case III. stabbing pains were complained of and were referred to the deposits, and the latter were very painful to examination.

We may say, therefore, that pains, shooting, burning, or stabbing in character, were present in all cases at various times in their history.

Some of the paroxysms observed in Case I. were particularly suggestive. Sometimes a welt-like swelling suddenly made its appearance, evidently following the course of a cutaneous nerve trunk and at the same time being exquisitely painful. After a time the swelling would become slightly less, but would never wholly disappear. Several such "welts" are still demonstrable in Case I. If the paroxysm of pain made its appearance in an area of old enlargement, that is, reappeared or recurred, a decided and sudden increase would take part in the swelling, and it would become for the time being firmer and more resistant and occasionally more nodulated than before, and generally a permanent increase in the swelling could be demonstrated. Further, it should be remembered that at one time some of the nerve trunks of the right arm were very sensitive to pressure, that some of the muscles, those of the thenar and hypothenar groups of either hand, revealed reaction of degeneration, and finally that the patient suffered on two occasions from herpes zoster.

In Cases II. and III. tenderness over the nerve trunks was not present at the time of the examination. In Case I., however, this symptom is also no longer present, its absence having been noted for some time past. This and other circumstances justify the assumption that Cases II. and III. were further advanced than Case I., and that the latter was really observed during a developmental period and while more active changes were going on.

Among the nervous symptoms must also be placed the diminished cutaneous sensibility and the patches of anæsthesia as well as perhaps the excessive weakness. It is probable also that the absence and the diminution of sweating belong to this category. It will be remembered that this symptom was undoubtedly present in Cases I. and II. and doubtfully in Case III. Lastly, headache was noted in all the cases.

Among other symptoms present in these cases should be noted hæmatemesis in Case I., hæmatemesis and epistaxis in Case III., and a recurrence of uterine flow many years after the cessation of menstruation in Case II. In Cases I. and II. the menopause occurred unusually early, namely, at thirty-five, and in Case II. menstruation was unusually free. In Case III. the menopause occurred at forty-six, and menstruation was likewise said to have been excessive. Finally, Case III. presented a well-marked purpura. What significance these symptoms may have, it is impossible to say. It may not, however, be out of place to recall the not infrequent occurrence of uterine hemorrhages in women who subsequently suffer from myxœdema.

Bronchitis was a most frequent and persistent symptom in Case I., while both Case I. and Case. II. suffered markedly from cardiac dyspnœa. But these symptoms were absent in Case III.

The fact that in both cases the thyroid gland was found indurated and much infiltrated by calcareous deposit is not only very interesting but exceedingly suggestive. Without microscopic studies, however, and without a more extended series of cases it is impossible to draw a conclusion. The part, if any, played by the thyroid in this curious affection can be determined only by future autopsies. It goes without saying, also, that the thyroid should be studied in every case of obesity, whether typical or otherwise, that reaches the post-mortem table.

With the above data before us, it is impossible to classify these cases under any well-established disease. Evidently the affection is not simple obesity. If so, how are we to dispose of the nervous elements present? It is equally certain that we have not myxœdema to deal with. All of these cases lack the peculiar physiognomy, the spade-like hands, the infiltrated skin, the peculiar slowing of speech, and the host of other symptoms found in myxœdema. It would seem, then, that we have here to deal with a connective-tissue dystrophy, a fatty metamorphosis of various stages of completeness, occurring in separate regions, or at best unevenly distributed and

associated with symptoms suggestive of an irregular and fugitive irritation of the nerve trunks—possibly a neuritis. This, however, does not embrace the whole truth, and it remains for future research to determine to what this neuritis is due, whether it is a cause of the fatty metamorphosis or only concomitant, and whether the thyroid gland does not play some mysterious part in its causation.

Inasmuch as fatty swelling and pain are the two most prominent features of the disease, the writer has proposed for it the name *adiposis* * *dolorosa*.

Since the above was written, three cases of adiposis dolorosa agreeing in all essential details with the cases described by the writer have been reported by Spiller.† Two cases have been placed on record by Eshner.‡ Another has been reported by Guidiceandrea; § and the case described by Ewald, in discussing the treatment of myxœdema, cretinism, obesity, etc., by thyroid extract, of a man who presented thick masses of fat about the nipples, the umbilicus, and the neck, with pains resembling those of neuritis, was doubtless an instance of this affection. Collins,‖ Peterson, and Loveland have also studied cases. *Francis X. Dercum.*

ADIPOSITAS.—(Synonyms: *Corpulence, Obesity, Polysarcia.* Cœlius Aurelianus and other of the older writers reserved the term polysarcia for extreme cases of the disease, but the terms are now used indifferently.)

DEFINITION.—Adipositas is a disorder of nutrition characterized by the deposition of an excessive amount of fat in many parts of the body.

The close relation which certain forms of adipositas bear to constitutional diseases, such as gout, arterio-sclerosis, and lipogenous diabetes, leads Krehl to place them in the same group.

It is frequently difficult to decide when the limits of normal stoutness are passed and the condition becomes pathological.

The amount of fat in a healthy adult is about one-twentieth of the body weight in the male and about one-sixteenth in the female (d'Heilly).

When the amount of fat is productive of symptoms, such as palpitation or breathlessness on slight exertion, difficulty in walking, or disinclination to take exercise, the' diagnosis of obesity is justified, even if an equal amount of fat is borne without discomfort by another person. The possession of a considerable amount of adipose tissue is of value in health. As it is a poor conductor it diminishes the amount of heat lost; and it represents a reserve capital to be drawn on in time of need, thus diminishing the drain on the tissue proteids.

The increase of bulk in obesity renders all bodily movements more and more difficult, and the increase in weight calls for the expenditure of more muscular energy. The muscles tire sooner, and there is a tendency to refrain from all avoidable movements. Disuse of the muscles is followed by atrophy; the disproportion between body weight and muscular power increases, and thus a vicious circle is established.

It is not rare to find corpulent subjects weighing three hundred pounds. Cases weighing four hundred and fifty pounds are frequent in the literature. These examples of monstrous obesity are more common among the English, Dutch, and Germans than among the French. The famous Daniel Lambert weighed seven hundred and thirty-nine pounds at the age of thirty-nine. There was a colored woman living near Baltimore who weighed eight hundred and fifty pounds. According to the *Medical Record*, there was a man in North Carolina of gigantic frame who weighed over one thousand pounds.

At the Boston City Hospital there have been seven cases of marked obesity among the last thousand autopsies, one subject weighing over four hundred pounds.

ETIOLOGY.—*Heredity.*—There is a hereditary tendency to obesity in about fifty per cent. of the cases. It is more frequently present in women than in men, but the disease may attack every member of a family. It usually does not appear till after the age of twenty or even later.

Similarly among domestic animals, particularly swine, there are certain breeds which are especially adapted for fattening. In all these cases there must be a special predisposition which leads to the deposition of fat under circumstances in which in a normal organism no fat would be formed.

Cohnheim believes that the oxidation of fat is abnormally low in these individuals, due to a reduction in the functional power of the tissue cells.

Age.—Corpulence is not uncommon in childhood, especially in America. It may occur even in infancy. Barkhausen reports the case of a male child, aged sixteen months, who weighed fifty-three pounds. Williams cited, many years ago, the case of a child who weighed one hundred pounds when one year old. Regnelle observed a child of eleven years who weighed four hundred and fifty pounds. Sometimes the abnormal stoutness is lost during adolescence. The least production of fat occurs between fifteen and twenty years of age. Obesity most commonly develops in the fourth and fifth decade. The fat is lost in old age. It is very rare among octogenarians and never is present in nonogenarians (Thompson).

The distribution of fat varies with the age. In the new-born the omentum and mesentery contain no fat even when there is a large formation elsewhere. So long as the growth in height continues these structures remain nearly free from fat. During middle life a large amount is deposited in the internal organs, and in old age it persists there after it has largely disappeared from the subcutaneous tissues (Oertel).

Sex.—Adipositas is more common in women than in men. Of one hundred and eleven cases collected by Bouchard seventy-five were in females. The hereditary form frequently manifests itself after the first pregnancy.

Over-feeding and over-drinking are the most potent factors in the production of obesity. As Osler well says, "the majority of people over forty years of age habitually eat too much," and, we might add, exercise too little.

Alcohol plays an important etiological rôle. In those countries in which the consumption of beer is greatest obesity is most common. Apart from the alcohol in the beer, the great quantity of fluid consumed, and the large amount of carbohydrates, more than five per cent., tend to fat production. Alcohol is readily oxidized, and thus saves the body fat from combustion; and it probably exerts a direct injury upon the cells, thereby diminishing their metabolic power.

Castration or sexual inactivity favors the deposit of fat. After the menopause there is a tendency for women to grow stout. Tilt found that of two hundred and eighty-two women examined, over forty per cent. became obese within five years after cessation of menstruation.

Anæmia.—After hemorrhage, and in chlorosis and other anæmias, there is often a rapid increase of fat. This is explained by the diminished oxidizing power of the blood, brought about by the loss of hæmoglobin, which is the oxygen carrier.

There are certain racial peculiarities worthy of note. Among the Hottentots there is a great accumulation of fat in the gluteal region. This is esteemed a mark of beauty. The Hebrews are especially prone to obesity. Climate and season exert little, if any, influence except as may be explained by habits and diet.

PATHOLOGY.—Fat can be formed from proteids and carbohydrates, or it can be directly stored up from the fat contained in the ingested food. The proteids are split into a nitrogenous and a non-nitrogenous portion. The

* Adiposis, as is well known, would be etymologically more correct if it were written adipositas, but adiposis has been so long in use that it must be regarded as established. Adiposis dolorosa has also perhaps a less formidable sound than has its Greek equivalent "lipomatosis algera."

† Spiller: Med. News, February 26, 1898, p. 268.

‡ Eshner: Journ. Amer. Med. Assn., November 12, 1898, p. 1156.

§ Guidiceandrea: Soc. Lancisiana degli Ospedali di Roma le Juillet, 1899; also Revue Neurologique, December 15, 1899, p. 877.

‖ Nervous Diseases by American Authors, Dercum, Philadelphia, 1895, p. 898.

latter is rich in carbon and can be deposited as fat or undergo oxidation and disappear. Increase of proteid food augments not only proteid metabolism, but also that of carbohydrates and fat. Hence an excess of proteid in the diet can actually lessen the fat of the body.

Pettenkofer and Voit fattened dogs by feeding only lean meat. The greatest amount of milk rich in fat was obtained by keeping a lactating bitch on a pure flesh diet (Subbotin, Kemmerich). Proteids can be changed into fat by the action of bacteria. This occurs in the ripening of cheese and in the formation of adipocere in dead bodies. Lindemann has demonstrated recently a formation of fat from proteid in skin preserved antiseptically. Under certain pathological conditions the appearance of fat in the cell has been explained, following Virchow's teaching, as a fatty degeneration of the cell proteids.

Pflueger and his pupils have always maintained that the formation of fat from proteids has not been proved. Athanasiu and Taylor, working independently, concluded that phosphorus poisoning has no effect upon the total quantity of fat. This leads them to believe that the fatty degenerations are really fatty infiltrations. Rosenfeld starved dogs and then fed them on mutton suet. It was deposited as such in the tissues. These animals were again starved and poisoned with phosphorus. The livers were fatty, but the fat was mutton fat that had been carried from other tissues and deposited there. The liver had lost but little of its nitrogen.

Toldt maintains that the deposition of fat occurs in a specific preformed tissue—adipose tissue. But according to the view of Virchow and Flemming there is no primary distinction between adipose tissue and ordinary loose connective tissue, and the fat cells are simply regular connective-tissue cells in which fat has been stored up. It is only where there is a rich blood supply that a deposition of fat occurs. Unna asserts there are three situations in which fat is formed—skin, muscles, and intestines.

Pathological Anatomy.—The excessive accumulation of fat occurs first in situations in which fat is normally present, namely, the subcutaneous tissues, the tissue underlying the serous membranes, the liver, and the bone marrow. Later it appears in situations where it is not normally found, as in the interstitial connective tissue of muscle, in the intermuscular tissue of the heart, and beneath the endocardium.

The arcus senilis usually develops prematurely.

The layer of subcutaneous fat over the abdomen is frequently 4 to 6 cm. thick. In one of our cases it measured 9 cm. Virchow records one with a layer 15 cm. thick. The fat is firmer in the plethoric than in the anæmic type of the disease. In young brandy drinkers it is said to have a peculiar tallow-like hardness (Rokitansky). The omentum and mesentery are loaded with fat.

The heart is sometimes entirely covered with a sheath of fat, and there is a fatty in-growth into the myocardium. Usually the fat is present in greatest quantity over the right ventricle. Fatty degeneration of the heart muscle is common; this, however, is often due to a terminal infectious process.

The masses of fat upon the chest wall, in the mediastinum, and about the diaphragm hamper respiration. Emphysema of the lungs and chronic bronchitis are found in nearly every case. The liver is greatly enlarged and infiltrated with fat. In one of our cases it weighed 4,555 gm. The surface is smooth and yellow. On section it has a greasy feel; the consistence is often soft.

The fatty capsules of the kidneys appear as great masses of fat, and there is a large deposit of fat about the renal pelves, and occasionally there is fatty infiltration of the renal tissue (Wagner).

Fatty metamorphosis of the pancreas has been recorded.

Arterio-sclerosis and fatty degeneration of the aorta and coronary arteries are common.

Blood.—In the plethoric type the hæmoglobin is frequently above one hundred per cent. Kisch found that seventy-nine out of one hundred obese patients had over one hundred per cent.; in one case one hundred and twenty per cent. In the anæmic form the blood has the characteristics of a secondary anæmia.

Free fat is sometimes demonstrable. According to Ritter the blood contains from four to five times the normal amount of fat. Achard and Clerc found the fat-splitting ferment sometimes increased in obesity.

Sexual Organs.—The sexual desire in man diminishes. The seminal fluid contains few spermatozoa, and sterility is common. The large size of the abdomen may render coitus impossible.

Skin.—There is increased secretion of the coil and sebaceous glands. Maceration of the epidermis and excoriation of contiguous surfaces are common, as are intertrigo and eczema.

Dilatation of the stomach is common. The intestine becomes distended; peristalsis is impeded and constipation supervenes. Weakening of the abdominal wall may give rise to fat hernias, most frequently in the linea alba between the umbilicus and the xyphoid cartilage.

Symptoms.—Most authorities follow Traube and Immermann in distinguishing two forms of obesity, the plethoric and the anæmic. Oertel adds a final class, the hydræmic, into which all cases may pass if the disease is not checked.

In the plethoric form the skin is ruddy, the muscles well developed, the blood rich in hæmoglobin. The appetite is keen, the digestion good. There is frequently great thirst. The blood tension is high, the pulse slow, the heart hypertrophied. Palpitation and dyspnœa develop on exertion. The patient is frequently troubled by vertigo and tinnitus aurium. Cardiac asthma is not uncommon and anginal attacks may occur. Later, dilatation of the heart takes place and the symptoms of broken compensation supervene.

Anæmic corpulence is more frequently hereditary than the plethoric form, and it is more common in women, while the latter chiefly affects men. Faulty assimilation and deficient oxidation rather than over-nutrition is the cause. The muscular system is poorly developed. The heart does not hypertrophy; the pulse is feeble. The masses of fat are flabby. The appetite is small and capricious; frequently there is an inordinate desire for food rich in carbohydrates. The symptoms due to anæmia are also present. Dropsy is common.

Diagnosis.—The plethoric and anæmic forms are easily distinguished. A blood examination is of value in diagnosticating the final stage of hydræmia. The urine should be carefully examined for sugar, so that lipogenous diabetes may not pass unrecognized.

Adiposis dolorosa is the term applied by Dercum, in 1892, to a symptom complex which should probably be classed as a separate disease. Since then cases have been reported by Collins, Spiller, White, and others. In two fatal ones the thyroid was diseased. All the cases have been in women. The onset usually occurs between forty and sixty years of age. Some have been drunkards, others syphilitic. Fatty masses appear on the trunk and limbs. The patient becomes generally obese, but fresh lumps continue to appear. Pain is a marked symptom; it may be present elsewhere than in the fatty deposits.

Complications.—Cardiac disorders are common. In six of our seven cases heart lesions were found at autopsy. The fatty overgrowth and infiltration also diminish the working power of the heart and the resistance of its walls. Sclerosis of the coronary arteries frequently leads to chronic myocarditis.

The relationship between obesity and sterility in the female was recognized by Hippocrates. Kisch has collected over two hundred cases associated with amenorrhœa and sterility. Philbert has described five cases in which pregnancy occurred after the corpulence was reduced. Abortion is common. Goubert records the case of a very obese woman who had eight consecutive abortions which he could attribute to no other cause.

The frequency with which corpulent persons are attacked with diabetes was pointed out by Trousseau and Seegen. Kisch asserts that more than half of the cases of extensive hereditary obesity become affected with dia-

betes mellitus. Generally the diabetes does not develop for years after the obesity has become marked. In these cases the progress of the disease is slow, glycosuria is almost the only symptom, and the prognosis is favorable. In another group of cases obesity appears in young individuals, develops rapidly, and diabetes in its severe form supervenes.

Gout is a frequent complication of obesity.

PROGNOSIS.—The outlook is more favorable in the plethoric than in the anæmic forms, and in the acquired than in the hereditary cases.

Acute infectious diseases are badly borne by the obese. This was known to the ancients. The internal temperature rises more quickly and is less readily reduced by cold baths (Liebermeister). Antipyretic drugs should be avoided.

Surgical operations are attended with grave danger. The resistance of the tissues to bacterial invasion is diminished. One of our cases, a very stout woman, was admitted with the diagnosis of strangulated umbilical hernia. At operation the sac was found to contain omentum only. Some omental and subcutaneous fat was removed and the wound closed. The temperature remained normal for seven days; then fever developed. Two days before death signs of thrombosis of the right femoral artery appeared. At autopsy, below the operation wound which had healed by first intention, a cavity was found in the subcutaneous fat of the abdomen the size of an orange, lined with necrotic material and containing dark-colored fluid. From this, and from the thrombi in the right iliac and femoral arteries and veins, pure cultures of the Staphylococcus pyogenes aureus were obtained.

This illustrates the truth of Sir James Paget's words: "The over-fat are certainly a bad class. . . . I know no operations in which I more nearly despair of doing good than in those for umbilical hernia or for compound fracture in people that are over-fat."

TREATMENT.—All curative methods aim to check the formation of fat and to rid the body of the accumulated fat. This is attained usually by restricting the diet and by increasing the oxidation processes. Systematic exercise is all-important.

In treating a case of obesity the general dietetic principles are: (1) to increase the animal food; (2) to diminish the fats and carbohydrates; (3) to diminish the supply of fluids.

The *Harvey-Banting method* was the first of the dietetic systems for the cure of obesity. It was devised by Mr. Harvey, of London, and used with great success in the case of William Banting in 1862. Animal food is freely allowed, the carbohydrates greatly reduced, and the amount of fat cut down to the lowest limit. The supply of water is not restricted.

In the *Ebstein method* the fats are increased, the carbohydrates greatly reduced, the proteids practically unchanged. A person whose diet is rich in fat requires less to eat and suffers less from hunger than one who, following Banting's treatment, has almost no fat in his food. Hence Ebstein includes butter and cream in his dietary.

The *Oertel method*, consisting of a combined dietetic and mechanical treatment, was first used in treating circulatory disturbances dependent upon heart disease. The loss of weight was so steady, and so pronounced, that he employed it in obesity. The fluids as well as the fats and carbohydrates are restricted. He believes that diminishing the water in the body aids in the reduction of fat, and that it also lessens the weakening of the heart muscle, which is the starting-point of most of the dangers of obesity.

The second part of the treatment consists of systematized exercise in the shape of walks and hill climbing. This produces combustion of the body fat, preserves the tissue albumin, and strengthens the heart.

The following is the diet recommended by Oertel:

"Morning meal: Coffee 4½ ounces, milk 1 ounce, sugar 77 grains, wheaten bread 1¼ ounces.

"Midday meal: Soup 3 ounces; roast or boiled beef, or veal, or game, or lean poultry, 7 to 8 ounces; fresh salad 1 ounce, bread 1 ounce, never to exceed 3 ounces; fruit 3 to 6 ounces; a little fish if desired. Light wine, 6 to 8 ounces, if no fruit, or if very hot weather; otherwise no fluid with this meal.

"Afternoon meal: Coffee 3¼ ounces, milk 1 ounce, sugar 77 grains, water 2 ounces, never more than 6 ounces; bread 1 ounce (exceptionally).

"Evening meal: Wine 7 ounces, water 2 ounces, one or two eggs, roast meat 5 ounces, salad 1 ounce" (Whitla).

The *Schweninger method* is somewhat similar to Oertel's. No water is allowed at meals, and the amount for the whole day is restricted to less than a pint. Hot baths and massage are important factors in the treatment. The passive exercises as described by Romme are severe, almost brutal.

In the Banting diet there is not sufficient fat to insure normal metabolism, and while this method is efficient in reducing fat, it is apt to produce exhaustion except in the very robust, and has been followed by sleeplessness, various nervous disorders, and even premature death. It is claimed that Oertel's method sometimes exerts similar injurious effects and, according to Rosenfeld, the reduction of fluid is frequently followed by kidney disease which leads to a fatal issue. Robin states that in cases in which the excretion of urea is diminished water should be freely allowed. In these cases restriction of the water supply would be injurious.

An adult male of average size doing a moderate amount of work requires about 118 gm. of albumin, 56 gm. of fat, and 500 gm. of carbohydrates. This equals 3,054 calories. It is interesting to compare this with the dietary of the chief obesity cures in the table given by Pfeiffer:

	Albumin, Gm.	Fat, Gm.	Carbohydrates, Gm.	Calories.
Banting	172	8	81	1,112
Ebstein	102	85	47	1,401
Oertel	183	38	143	1,690

Bouchard has obtained excellent results on a diet of milk and eggs. No other food is allowed for a period of twenty days. The patients are usually greatly constipated.

Sir Dyce Duckworth recommends a dietary more liberal and less irksome than that of Ebstein or Oertel—12 to 14 ounces of meat, 6 to 8 ounces of bread, 4 to 5 ounces of green vegetable, 1 to 1½ ounces of butter and fat, and 30 to 35 ounces of fluid.

Thyroid Treatment.—The use of thyroid extract in adipositas was advocated first by Yorke Davies and soon after employed by Leichtenstern in Germany. This agent has been successful in some cases, especially those of the anæmic type. The dosage is one to five grains given thrice daily. If the dose is increased to ten grains symptoms of thyroidism usually supervene—marked headache, tachycardia, syncope, etc. Love states that strychnine is a valuable adjuvant to the thyroid treatment.

The loss of weight is not constant. In some cases it does not occur. Achard and Clerc record a gain of weight in one case. Ebstein in a recent article brings some weighty objections against this method. He says that the gland loses its effect after a time; the storing up of fat begins again when the treatment is stopped; finally the loss of weight depends more on increased proteid metabolism than on the disappearance of fat. Dietetic measures are less dangerous, as von Noorden has shown that a reduction of fat can be effected by a dietetic mechanical treatment without the loss of albumin.

Von Hoesslin conducts his treatment along four lines: First, proteid-fat diet resembling Ebstein's; second, hydrotherapy; third, thyroid extract; fourth, regular exercise.

Mineral waters have long been regarded of value in the treatment of obesity.

Cathell recommends a course of Vichy and Kissingen waters. They are used alternately, each for a day, a large glass a half-hour after each meal.

These alkaline and saline waters are effective only in so far as they remove fat-forming substances of the food from the intestine by increased peristalsis before absorption can take place.

Baths are of value in increasing metabolism. Hot baths and vapor baths are especially recommended.

Sleep should be restricted to seven or eight hours.

Joseph H. Pratt.

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ADIRONDACK MINERAL SPRING.—Washington County, New York.

POST-OFFICE.—Whitehall.

The water of this spring is found in the markets under the name of the Adirondack Medicinal Water. An analysis by Professor Collier, of the University of Vermont, shows the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	5.14
Potassium carbonate	5.32
Calcium carbonate	18.54
Magnesium carbonate	16.62
Lithium carbonate	0.02
Manganese carbonate	Trace.
Iron carbonate	5.04
Calcium sulphate	11.13
Sodium chloride	14.34
Alumina	Trace.
Silica	0.74
Total	76.89

This analysis shows an excellent chalybeate water. Experience has shown its efficacy in cases of anæmia and general debility, in subacute and chronic articular rheumatism, in muscular rheumatism, and in some of the scaly skin affections. *James K. Crook.*

ADIRONDACKS.—This extensive forest and lake region is a plateau studded with mountains and lakes and situated in Northern New York, between lat. 42° 30' and 44° 30', long. 74° to 75° 30' W., being, roughly estimated, 125 miles square.

The average elevation is 1,600 feet, the mountain peaks varying from 2,000 to 5,000 feet, trending in general toward the southwest in several irregular ranges.

The northern and southern boundaries are gradual slopes to the St. Lawrence and Mohawk valleys respectively, while the eastern is more abrupt to Lakes George and Champlain, and the western less so to Lake Ontario.

Geologically, this region is related to the Archean or earliest formation, with glacial drift and moraines much in evidence.

The soil is chiefly light sand, which forms a feature of importance in determining the climate and character of the forest growth.

The lake shores, lowlands, and valleys are wooded chiefly with fir, pine, white cedar, tamarack, red spruce, and balsam. The lesser elevations and foothills have deciduous trees in greater proportion, such as sugar maple, birch, beech, poplar, mingled with a few evergreens, while the majority of the peaks are wooded to the top with firs and spruces.

The combination of dark-green-clad mountains and numerous island-dotted lakes gives at all seasons a landscape of great beauty.

Large tracts of forest are owned by the State and individuals for permanent preserves, insuring protection for fish and game and conserving the water supply. Temporary camps are permitted on State land, and during the trout and deer seasons great numbers of sportsmen find delight in these haunts. Modern camp life for the invalid or convalescent in the Adirondacks is a pleasure hardly surpassed, when all the luxuries are available.

The climate has long been noted for its invigorating qualities. The winters are usually cold and dry, the summers cool but moist, though relatively dryer than coast climates or lowlands.

The porous soil, elevation, and coolness render the moisture less apparent, though the rains are very frequent in summer. Meteorological data for the past six years are now available for the comparison of different sections of the plateau. The mean annual temperature for the whole region is 42.8° F.; average total precipitation, forty-two inches.

The prevailing winds are west and southwest, being much varied and retarded by the mountains and immense areas of forest. The coast winds do not reach inland far enough to affect the climate, but Lake Ontario modifies the western slope, while the northern part is influenced more by the St. Lawrence valley winds, which, especially in winter, sweep across the level plains of Canada from the west.

The precipitation is greater on the southern and western slopes than in the interior and northern portion of the Adirondack plateau, though local conditions appear to influence the amount greatly. Thus at Saranac Lake, in the northern centre, the average annual precipitation for six years was thirty-four inches, yet in the forest, within a few miles, it is manifestly much greater. At the same place the annual mean temperature was 41.7° F., and for the four winter months 19.5° F., with an average of ten rainy days for the winter. The mean summer temperature was 62° F.

Quoting from the Annual Report of the New York Weather Bureau, 1896: "The Adirondack plateau is subject mainly to the same influences which determine the climate of the St. Lawrence valley, excepting that the central and eastern portions of the highlands are not reached by the lake winds. A very broken and heavily timbered surface offers great obstructions to the circulation of air currents, and hence the summer temperature, although the lowest in the State, is somewhat higher than would otherwise be, due to the elevation of the region. . . .

"So far, then, as present records show, the whole of Northern New York has substantially the same average winter temperature, except as certain deep valleys are subject to a local cooling through an accumulation of the colder and denser air. In summer the warmth of the highlands decreases at about 0.3 degree per hundred feet of elevation above sea level, and the average temperature of the Adirondack region at that season is thus reduced to nearly the same level as that which prevails on the seacoast of Northern Maine; the days, however, being warmer and the nights cooler than in the coast region."

There is an excess of cloudy weather in November, December, April, May, and frequently at other seasons; the virtues of the climate being attributable to coolness, altitude, aseptic atmosphere, freedom from dust, rather than to the amount of sunshine.

The suitability of the climate for the cure of early tuberculosis has been amply demonstrated, and arrest or amelioration of advanced cases is secured by a prolonged residence, when the powers of resistance can be stimulated. It has been found beneficial, particularly in summer, for chronic bronchitis and asthma dependent upon it, also for hay fever. The winter is equally good, if not better, for early tuberculosis. It is unsuited for rheumatics, renal cases, and patients beyond middle life.

The principal resort, Saranac Lake, is generally known because of the Adirondack Cottage Sanitarium, founded by Dr. E. L. Trudeau, for tuberculous patients of moderate means. This establishment has one hundred rooms, and was the first people's sanatorium of its kind in America. Twenty-five per cent. of all cases and from sixty to

seventy-five per cent. of the incipient class are discharged apparently cured. One other institution is at present available in this region—the Sanitarium Gabriels, located at Paul Smith's Station, and accommodating sixty patients.

A list of the various resorts in the Adirondack region, with their respective elevations, is appended. Further information can be found in Solly's "Medical Climatology," in Knopf's "Pulmonary Tuberculosis," in guide-books, etc.

Resort.	Elevation.
Saranac Lake	1,535 feet.
Lake Placid	1,863 "
Tupper Lake	1,546 "
Keene	1,000 "
Elizabethtown	759 "
Old Forge	1,684 "
Fulton Chain	1,700 "
Paul Smith's	1,623 "
Saranac Inn	1,560 "
North Elba	1,885 "
Chazy Lake	1,500 "
Blue Mountain Lake	1,800 "
Schroon Lake	806 "

E. R. Baldwin.

ADONIDIN (*Adonin*).—A glucoside obtained from several species of *Adonis*, chiefly from the root of *A. vernalis* L. It is a light-yellow powder, without odor, but intensely bitter, very hygroscopic, soluble in both water and alcohol. Moisture must be carefully excluded from the containers. As it exists in commerce, it is a mixture of variable degree of purity. Its action is described under *Adonis*. The dose is 0.004 to 0.016 gm. (gr. $\frac{1}{16}$ to $\frac{1}{4}$).

Picradonidin is merely the very pure form of adonidin.

H. H. Rusby.

ADONIS.—*False Hellebore* (family *Ranunculaceæ*). The herb of *Adonis vernalis* L., one of some sixteen species in the genus.

It is a small plant, growing wild in Southern Europe, and somewhat cultivated as an ornamental flower. Owing to the instability of its active constituent, adonidin, it should be carefully preserved in a cool and dry place and should not be kept on hand too long. The plant is poisonous.

Besides the active constituent described above, it contains aconitic acid to the extent of ten per cent. The action of adonis is apparently due altogether to the adonidin, which exists to the extent of 0.02 of one per cent. Its effects are for the most part exerted upon the circulation. Its first and chief action is to stimulate the vasomotor centres and thus greatly increase blood pressure. Next it stimulates the heart directly, increasing both its rate and force, and thus still further increases the blood pressure. This pressure then reacts against the heart and may slow it. If the dose is larger, the inhibitory centres are stimulated, and this markedly slows the heart. The same causes render it a powerful indirect diuretic. The vasomotor stimulation is not long continued, and is succeeded by depression, as is to a less extent the direct cardiac stimulation, the two together causing a sudden fall in blood pressure. If the dose is a poisonous one, death will occur with the heart in diastole. Large poisonous doses cause vomiting and purging. The treatment of poisoning is entirely physiological and symptomatic.

Adonis is used in exactly the same way as digitalis, as a cardiac and arterial stimulant, and is liable to the same contraindications. The greatest difference of opinion exists as to which is preferable, but it appears established that adonis, at least in the form of adonidin, acts more quickly, though the action is not so prolonged, and is more apt to be followed by reaction. No attempts have been made to ascertain whether the tissue of the heart muscle is permanently changed in quality or quantity by adonis, as appears to be the case with digitalis.

Adonis is best given in the form of tincture or fluid extract, which are miscible with water, or as adonidin. The dose of adonis should represent 0.05 to 0.25 gm. (gr. i. to iv.). It is best to begin with a small dose and increase gradually.

H. H. Rusby.

ADRENAL GLANDS.—ANATOMY.—The adrenal glands, formerly known as *capsulæ atrabiliariæ*, from the dark brown color sometimes seen in the medullary portion after death, or *renes succenturiati*, also called suprarenal bodies, or capsules, are classified as "ductless glands," together with the spleen, thyroid, and thymus, since they have no excretory duct. They are situated in the epigastric region, one on either side of the vertebral column, in the posterior part of the abdominal cavity, behind the peritoneum, and they surmount their respective kidneys to which they are attached by connective tissue.

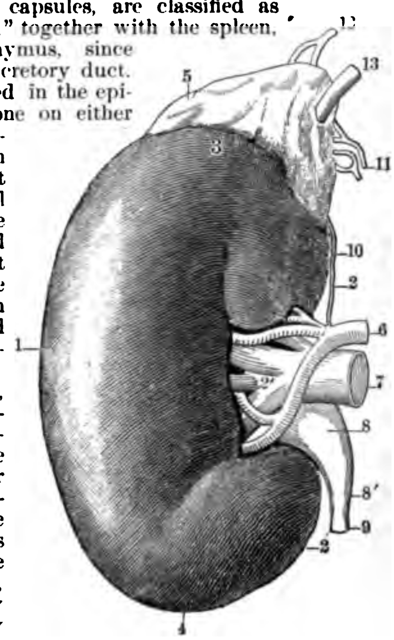

FIG. 48.—The Kidney and the Adrenal Gland of the Right Side. Anterior view. (From Testut: Traité d'anatomie humaine, vol. iii.) 1, External border; 2, internal border with 2' hilum; 3, upper extremity; 4, lower extremity; 5, adrenal gland; 6, renal artery with its branches; 7, renal vein; 8, pelvis with 8' neck of pelvis; 9, ureter; 10, inferior adrenal artery; 11, middle adrenal artery; 12, superior adrenal artery; 13, large adrenal vein.

They are flat, yellowish, glandular bodies, differing from one another in their shape and relations. In the fœtus these glands are larger than the kidneys, but later, although they continue to grow till adult life, they increase in size more slowly than the kidneys, and consequently the difference in the relative size of the two organs in the fœtus and in the adult is very striking. Thompson thought that this preponderance of the adrenal in the fœtus was a peculiar characteristic of the human gland not shared by that of any other mammal. In childhood these glands are firm and partly translucent at the edges, and they do not contain much fat, whereas this element appears to increase in amount with the age of the individual. The healthy adult organ is never translucent and is less firm than in early age.

The right adrenal is triangular and flattened and has been likened to a cocked hat. It presents two surfaces, anterior and posterior. The anterior surface has three angles, superior, inferior, and external. It is divided into two parts by a groove called the hilum. This groove runs horizontally from the upper outer margin inward, a little below the upper border, then curving downward at the emergence of the capsular vein it runs vertically a little internal to the median border. The upper and inner part of this surface is somewhat depressed, and comprises about one-third the whole area. Its superior part is in direct contact with the liver, while the median part lies behind the inferior vena cava. The external two-thirds of the anterior surface of the capsule is separated from the liver by its covering of peritoneum, except a small area about the inferior angle, which is in contact with the duodenum. The posterior surface is also divided by a furrow into the upper larger part lying against the diaphragm and the lower smaller part which lies in contact with the kidney.

The left adrenal is a little larger than the right and is

not so prominent above its respective kidney, but it extends downward along the upper half of its median margin. It has two angles, superior and inferior. From the anterior view, its outline is rather semilunar or crescentic, its concave surface looking downward and outward toward the kidney. It also presents two surfaces, anterior and posterior. The anterior surface is traversed by a furrow which passes downward and forward, and from its lower end emerges the suprarenal vein. The superior part of the anterior surface lies in contact with the spleen and the cardiac end of the stomach, while the lower part is covered by the pancreas and splenic vessels. The posterior surface is divided by a vertebral elevation so that the inner part is directed inward and backward and is in contact with the left crus of the diaphragm, while the external part looks outward and backward and rests against the kidney.

Structure.—The gland on perpendicular section is seen macroscopically to consist of two parts, cortex and medulla. It is surrounded by areolar tissue in which there is much fat. Besides this covering, it is invested with a fibrous envelope consisting of two parts, the outer of which is looser and the inner of closer, firmer structure. Flint has shown by chemical manipulation that the periglandular connective tissue and a large part of the external layer of the capsule consist of white fibrous tissue. This fibrous envelope has connective-tissue cells, smooth muscle fibres, nerves, and ganglionic cells which are derived from the neighboring plexus cœliacus. Stilling first described the superficial plexus of lymphatics of the adrenal, in addition to which there are the arterial and venous plexuses.

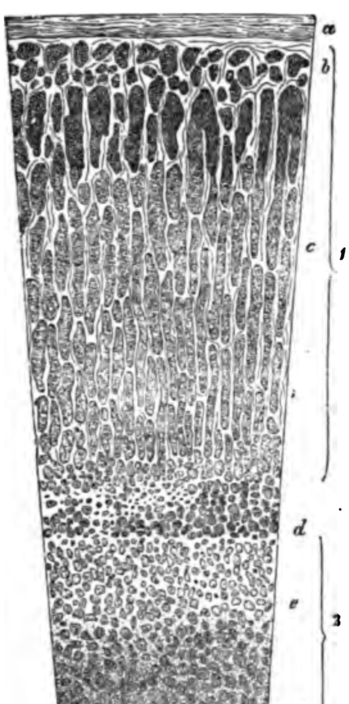

Fig. 49.—Vertical Section of Adrenal Body: Human. Magnified. (Eberth.) 1, Cortical substance; 2, medullary substance; *a*, capsule; *b*, zona glomerulosa; *c*, zona fasciculata; *d*, zona reticularis; *e*, groups of medullary cells; *f*, section of a large vein.

Cortex.—The cortical part is deep yellow in color and compact in consistence. It forms the larger part of the organ. On examination three zones are discernible: the external, *zona glomerulosa*; the middle, *zona fasciculata*; and the internal, *zona reticulata*—these names indicating the general appearance of the individual layers. The framework of the gland consists of reticulum. This substance is not yellow elastic tissue, since it resists pancreatic digestion, as shown by Ewald and Kühne. Neither is it white fibrous tissue. Mall has shown its difference in chemical nature and reaction from the latter, as well as from the elastic fibres. He has also proved that the interstitial tissue of many glands and organs has no connection with the connective-tissue cells, but consists of an interlacement of branching fibrils. This substance he calls reticulum. It is very abundant in the splanchnic area. As the result of chemical manipulation it yields a residue called reticulin. From the inner part of the capsule particularly, two kinds of processes extend into the gland. These are the large septa, which reach nearly, if not completely, to the zona reticulata, and the smaller septa, which divide the outer part of the cortex into irregular oblong spaces in which are found the coiled columns of cells that form the zona glomerulosa. These spaces are still further divided by reticular processes which separate the cell columns. The cells of the zona glomerulosa are irregularly columnar or cylindrical in shape, having small oval nuclei nearly central in position. Flint, in describing the zona fasciculata of the dog, says that the reticulum takes origin from the larger septa which spring from the capsule and from those at the inner border of the zona glomerulosa. These filaments reach toward the medulla, twining in and out between the cells. The anastomosing cell columns of the zona fasiculata lie at right angles to the capsule and are composed of polyhedral cells. Capillaries and fibrils of reticulum coming from the capsule and septa of the zona glomerulosa give to this layer its columnar arrangement of cells. The cell columns of the zona fasciculata of the human adrenal are distinctly outlined, the capillary endothelial nuclei assisting in great measure to make them clear. The filaments of the zona reticularis are derived from the layer above, and their structure is so complicated that Arnold has declared that practically each cell has its individual space. Many of these fibrils run parallel to the capsule, a direction at right angles to their course in the zona fasciculata, although the meshwork is so dense that the separate fibrils can be followed for only a short distance. This zone separates the rest of the cortex from the medulla, and in some animals is very irregular. The cells of the zona reticularis in the human adrenal are large, containing, as well as albuminoid and fat granules, brown pigment, which is more abundant in adults than in infants and children.

Medulla.—The medullary part of the adrenal in the adult is soft and pulpy and of a dark brownish-black hue. After death it quickly changes, becoming rapidly almost diffluent. Its first appearance in the embryo is indicated by small groups of cells under the capsule after the cortex has been formed. These cells gradually migrate toward the centre of the gland, and in doing so they increase in size and intricacy, but it is not till just before birth that a hint of the arrangement of the cell groups appears. The shape of the cells is polygonal; they are larger than the cortical cells; they are destitute of oil globules, and are arranged in round, oval, or irregularly crescentic groups, enclosed by the reticular septa. The reticulum of the medulla is derived from that of the zona reticularis, and its appearance is quite like that of the zona glomerulosa, although far more delicate. The differentiation of cortex from medulla is very distinct, not only by the gross appearance, the cortical framework being very dense in contrast to the looser medullary septa, but also by the characteristic reactions. This is particularly shown in the different effect of the salts of chromium on the cells of the two parts, the cortical cells giving no reaction, and the medullary cells staining a dark brown. This is generally known as Henle's reaction. The protoplasm of the cortical cells stains more deeply with ordinary stains than the cytoplasm of the medullary cells.

Flint has described several curious anomalies in position of the cortical and medullary cells which are not infrequently seen, all of which point to the embryology of the gland. These appearances have caused much confusion in the literature. The centrally migrating medullary cells sometimes cut off islands of cortical cells, which on this account remain in the medulla even in adult life. Islands of medullary cells are found in the cortex. A medullary cell group may not be closed over by cortex, and so at this point medulla may extend from the periphery of the gland to the central vein. The medullary cell groups may not joint laterally, and so a cortical column will extend from the centre to the periphery. Flint notes one curious case in which at a certain point in the gland the medullary cells failed to grow inward, and

Adrenal Glands.

so the cortex was found in its embryonic situation about the *vena centralis*, while the medullary cells remained beneath the cortex.

Blood-Vessels.—The arteries of the adrenal are derived from three sources, viz., from the aorta, the phrenic, and the renal arteries. Flint observes the variations of pressure and velocity in the different regions from which the adrenal arteries originate, and points out the fact that the circulation of the adrenal gland must depend to a certain extent on that existing in these various regions. He says "that the arterial system of the body is a record, to a considerable degree, of the ontogeny of its parts. For example, the course of the spermatic artery is a permanent record of the path followed by the testicle in its descent." From his work on the adrenal he has shown that what is true of the general circulation is also true of the circulation of individual organs. "Thus the course of the arteriæ medullæ through the cortex of the suprarenal body defines the path followed by the medullary substance from its embryonic to its adult position." In describing the adrenal circulation in the dog, this author speaks of the capsular plexus formed by the arteries, from which originate the three channels which nourish the three different parts of the gland and through which the flood flows into the veins. This blood from the arterial plexus passes through two sets of channels: (*a*) the arteriæ capsulæ and (*b*) the arteriæ corticis. The first of these, the arteriæ capsulæ, subdivide into capillaries throughout the capsule, and finally empty into the capsular venous plexus. This lies just underneath the arterial plexus. From the former, by means of the venæ comites of the adrenal arteries and by other independent veins emptying into the *vena lumbalis*, the venous blood is carried from the capsule. The second set, the arteriæ corticis, pour their blood into the capillaries of the zona glomerulosa, from which channels it passes into the capillary system of the zona fasciculata, and still on into the capillaries of the zona reticularis, whence it finally reaches the medullary boundary, where the smaller venules anastomose, forming branches which empty into the *vena centralis*. The arteries of the medulla spring from the cortex and reach the medulla without anastomosis. There they form a plexus. From this the blood flows away by two routes: (1) directly into the venous tree; (2) indirectly, by means of veins which empty into the central vein itself or its large branches. The venous tree is a tributary of the lumbar vein, the junction of the two being at the hilum of the gland. The venous tree, whose finer twigs are seen at the periphery of the medulla, is made up of true terminal veins, excepting the very finest branches. Those veins of the capsular plexus which empty into the *vena lumbalis* are provided with valves, while none are found in the trunks of the venous tree. Thus in this locality the medullary circulation depends to a degree on that of the lumbar vein. According to Testut, independently of the central vein, the surface of the capsule gives rise to other veins which follow more or less the course of the arteries, some of them emptying into the diaphragmatic veins, others into the renal veins. Testut also states that the adrenal veins are remarkable for the development of their muscular coat.

Nerves.—As to the nerve supply of the adrenal, Quain says that it is particularly rich and is derived from the solar and renal plexuses. Bergmann thinks that it is also supplied by the phrenic and pneumogastric nerves. The nerve twigs are especially numerous in the cortex, where they penetrate between the cells, particularly in the zona glomerulosa. In the medulla, numerous ganglionic cells are found. Before entering the cortex there are many ganglionic cells on the nerves, and the fibres are chiefly medullated. Flint thinks that these cells and fibres have no organic connection with the gland, but have been drawn in by the medullary cells, although he adds that there may be sufficient nerve supply to govern the medullary secretion.

Lymphatics.—According to some authorities the lymphatics take their origin between the cell groups and form a rich network both in the cortex and in the medulla. They form a particularly dense plexus about the central vein, and run in the general direction of the vessels. They are connected with efferent valved lymphatics both in the fibrous capsule and in the medulla, and on the external surface of the gland some of them blend with the superficial lymphatic network, while the others empty into ganglia a little above the renal vein. These ganglia into which the adrenal lymphatics empty are distinguished from their neighbors by their rich pigment. Flint has discovered lymph nodules in the medullary substance of the gland, and irregular groups of lymphatic cells in the cortex of the human adrenal. He, however, declares that our knowledge of the adrenal lymphatics is still most unsatisfactory, and he believes that the lymphatic channels have never as yet been definitely traced out as a system, nor have their relations to the cells and blood-vessels been yet discovered.

The average size of the adrenals is from 1¼ to 2½ inches (30 to 60 mm.) in length by about 1¼ inches (30 mm.) in breadth. The thickness varies from ⅙ to ¼ inch (4 to 6 mm.). The weight is about 1 drachm (4 gm.), the left being slightly heavier than the right.

ANOMALIES OF DEVELOPMENT.—One or both of the glands may be absent, although this condition is very rare, and the defect is probably supplied by accessory glands, which, as Stilling has shown, can undergo compensatory hypertrophy. Ziegler says that hypoplasia and agenesis of the adrenals are usually found in anencephalous and hemicephalous fœtuses. Dyce Duckworth says: "In cases of congenital absence of one kidney it is usual to find a suprarenal body in its proper situation. This fact plainly indicates that there is no embryological connection between the kidney and the adrenal body, and they are thus physiologically distinct."

Accessory Adrenals.—These additional glands are not unusual; they vary in size from a pin's head to a cherry —Allbutt having seen one of the latter size. These tiny bodies are found generally on or near the capsule itself and are joined to it by connective tissue, or they may be partly embedded in the liver or kidney, and in this situation they are called "rests." They have been seen on the spermatic vessels near the inguinal canal, and in the broad ligament. Rolleston speaks of tiny elevations on the surface of the adrenal which he calls adenomata and which are composed of adrenal cells in an extreme state of fatty infiltration. They are not accessory glands, differing from them in that the latter possess a capsule of their own and are made up of cells which show little fatty infiltration. Swale Vincent says: "The suprarenals are very intimately related to the blood vascular system. This relationship is most striking in elasmobranchs, but is still evident in mammals from the very large blood supply to the organ and its close anatomical connection with the great veins." Various and interesting have been the theories concerning the origin of the adrenal elements. By some the cortex was thought to be derived from the mesoblast, while the medulla took its origin from the sympathetic nervous system. Others thought that the medulla was derived from the cortex. The latest work seems to show that this question is not yet definitely settled, although it seems certain that the medulla is not derived from the cortex.

PHYSIOLOGY.—Physiologists classify the secretions of the body under two general heads, internal and external secretions. The idea of internal secretion took its origin with Claude Bernard. It is defined, according to Osler, as consisting of certain products elaborated by gland cells from materials furnished by the blood, which are later passed back to the blood or lymph to subserve some function in general or special nutrition. External secretion is poured out on a free epithelial surface communicating with the external world. Internal secretion is discharged on the closed endothelial surfaces of the blood and lymph vessels.

Among the glands which have an internal secretion are the adrenals, and many investigators have contributed their work to the very intricate problem of the elucida-

tion of the exact functions of this gland. Schäfer says that as early as 1855 Addison showed the great importance of these glands in relation to nutrition, since their pathological alterations were thought to be connected with asthenia and the bronzing in patches of the skin and mucous membranes. In 1856, and subsequently, Brown-Séquard showed that their removal was always rapidly followed by death in all animals. It is interesting to note that removal of one gland has apparently no untoward effect. But when the second is taken away, even though the interval between the two operations may be a long one, the fatal symptoms quickly supervene. They are practically those of Addison's disease, though more acute than the latter—asthenia, loss of vascular tone, anorexia, and general prostration. The peculiar pigment characteristics of this disease are not always noticed, probably due to the fact, as Brown-Séquard suggested, that there is no time for its development between the ablation of the capsules and the death of the animal. Tizzoni has experimented on animals which have lived a certain time after either complete or partial removal of the glands, and has in these cases observed the pigmentary changes. The cause of death seems due generally to paralysis of the respiratory muscles. Experiments by Brown-Séquard, Abelous and Langlois tend to show that blood taken from an animal which is dying from the effects of "decapsulation" has no effect on normal animals, although it is toxic for animals more recently deprived of their adrenal glands. On the other hand, normal blood transfused into animals deprived of their capsules seems to prolong life. Since muscular weakness is the most prominent symptom after removal of the glands, the conclusions of Abelous and Langlois are that the capsules when *in situ* remove or destroy some toxic substance which is the result of muscular metabolism. Observations of these experiments has suggested the "auto-intoxication" theory of the adrenal glands. This theory, like all others of its kind, is weak in that the blood of any dying animal would probably be toxic to a certain extent, and also in that the animal on which its effect is observed is, on account of its recent operation, in a state of lessened resistance to any toxin. Nevertheless, it must be admitted that the adrenal glands elaborate some material which is very different from any found in the blood of animals deprived of their capsules. The intravenous injection of the adrenal extract is most active in its physiological working. Schäfer sums up these effects as follows: First, as to its action on skeletal muscle. After one excitation of its nerve, the muscle contracts as quickly as the normal, but this contraction is extremely prolonged. The effect is like that of a small dose of veratrine, but not of curare, for the muscles continue to be as capable of excitation as they were previous to the injection. It can thus be clearly seen that these phenomena are very different from the "so-called auto-intoxication paralysis which is stated to result after removal of the suprarenal capsules in animals." Consequently the material which has been extracted from the adrenals by water is not the same which is said to collect in the blood after ablation of these glands. The effect on the circulatory system is shown in two ways—on the arteries and on the heart. As to the latter, the effect depends upon the condition of the vagi. When these nerve trunks are uncut and the connection, therefore, between the heart and the cardio-inhibitory centre in the medulla is still intact, the contractions of the auricle are slowed, or they entirely cease after the injection of the extract. The ventricle continues to beat slowly. The pulse is necessarily very slow. But if the vagi are cut or their cardiac ends paralyzed by atropine, the effect of the extract is exactly the reverse. The auricle is more energetic in its contractions, both their strength and frequency being much increased, while the functions of the ventricle are likewise augmented. All of these phenomena cause a great increase in blood pressure by sending a much larger quantity of blood into the arteries. But besides this, the extract has a direct effect on the arteries themselves, for if the blood pressure be taken in a dog and then a small injection of the extract be made, the vagi being uncut and therefore the heart action being slowed, the blood pressure increases to quite an extent; but if the vagi are cut or paralyzed by atropine, the rise is extreme. If a certain member of the body be enclosed in a plethysmograph, the effect of the extract is clearly shown in the decrease of the member in size, due to the contraction of the arterioles. This effect is exerted directly on the musculature of the vessels, since it appears as markedly when the spinal cord is cut or the bulb extirpated. Schäfer does not believe in the view of Cybulski and Szymonowicz, that the rise in blood pressure and the contraction of the arteries are due to the excitation of the vasomotor centre; for, as his experiments show, this effect is peripheral. In the bulb he states that especially the cardio-inhibitory and respiratory centres are affected. In certain experiments on dogs the first effect of the extract has been excitement, this being followed by paralysis, while great thirst was experienced by these animals. In cats, rapidity of the respiratory movements was noticed, as well as thirst and loss of appetite. Recently strong astringent properties have been observed. As a local styptic it has given potent effects. Meyers, in experiments with various organs, discovered that the adrenal body is alone found capable of neutralizing cobra poison. Guinea-pigs and sheep give the same results. The medulla is found inactive, the cortex and the entire gland active. Oliver has demonstrated that the extract when applied directly to the mesenteric vessels, either in the living or in the "surviving" animals, causes rise of blood pressure. Von Cyon, in reviewing the different theories of various workers, states that they all agree as to the increase of blood pressure caused by the intravenous injection of the adrenal extract, but not as to the influence which it exerts on the heart action. Oliver and Schäfer think this latter due to the excitation of the musculature of the small arteries, as well as of the heart vagi. Cybulski and Szymonowicz think that the extract has a special influence on the vasomotor centre of the vessels. Gottlieb believes the motor heart ganglia to be chiefly affected. Von Cyon himself believes that the extract of the adrenal gland acts in a high degree as a stimulant to the sympathetic nervous system of the heart and the vessels (accelerantes and vaso-constrictors) and also as a paralyzer to the regulatory (motor) nerves of these organs (vagus and depressors). So this extract is a powerful antagonist of iodothyrin and hypophysin. Schäfer describes the effect of the injection of the extract as quite transitory, even if the dose be large. This fact presents the interesting problem of the disposal of this extract—where is it eliminated? The kidneys are not its route of exit, for when the renal arteries are clamped, the effects are just as fleeting. Just so with the suprarenals. If the circulation in the abdominal organs is entirely stopped by tying the aorta and vena cava in the upper abdomen, the effects are nearly as short in duration. The blood does not oxidize or destroy the active principle of the extract, for after twenty-four hours' contact with this fluid the power of the extract is as great as normal. It seems logical to conclude that the active principle is stored away somewhere in the body and there rendered harmless, and, since the effects endure much longer in the skeletal muscles than in the heart and arteries, that the muscles are the great storage house.

Now as to the effect of the extract when administered hypodermically or by mouth, results by the former method vary exceedingly, depending on the animal experimented on and the dose injected. Oliver says that in man the extract, when given by the mouth, has the effect of reducing the calibre of the arteries, as measured by the arteriometer.

As in every other line of research in relation to these organs, so have there been varied and contradictory results concerning the chemical nature of their active principle. Abel has shown that the "specific blood-pressure-raising constituent" exists in the embryonic gland. At just what stage it first appears has not been determined. Oliver believes that the peculiar properties of this principle are due to an alkaloidal body and not to

the proteid elements. The substance is not dialyzable, consequently its molecule is probably very large. Cybulski, Oliver, Schäfer, and Swale Vincent believe from their work that the active principle is found only in the medulla, and that the cortex yields no appreciable amount. Schäfer and Oliver believe in the internal secretion theory which promulgates the idea that a certain substance is formed by these glands and passed out into the blood, which has a beneficial effect on the muscular contraction and tone of the cardiac and vascular walls and on the skeletal muscles.

Allbutt calls these two theories that we have mentioned, one as the auto-intoxication theory, the other as the internal secretion theory: (1) The excretory or katabolic, which supposes that the adrenals dispose of waste materials in the blood; (2) the secretory or anabolic, which supposes that they elaborate some substance necessary to the animal economy and pass it into the circulation. Other authors, Byrom Bramwell and Boinet, have recently combined the nervous and the "adrenal inadequacy" theories by suggesting that in Addison's disease the symptoms are caused by irritation and neuritis of the sympathetic as well as by the pathological suppression of the extract.

Dreyer, in his work in 1899, has shown again what Cybulski first proved, that the active principle of the adrenal extract can be obtained from the blood of the adrenal vein; consequently it is a true internal secretion. He has further proved the influence of nervous control over the secretion, for if the splanchnic nerve below the diaphragm be stimulated by an electrical current, the amount of this active principle in the secretion is augmented, judging from the increase in the physiological effects caused by the extract. This increase has no connection with the blood vascular changes which take place at the same time. The objection was formerly raised that the active principle was found only in the dead gland, but the proof that blood collected from the adrenal vein, and from no other, has the same effect as the extract itself, establishes the significance of the reactions of the gland. Dreyer has also demonstrated that intravenous injection of the extract in a normal animal causes slowing of the heart and an increase of blood pressure, while after the vagi are cut or atropinized the heart beat is quickened and the blood pressure increases to a still greater degree. From the experiments of Oliver and Schäfer, Swale Vincent, and Dreyer, it would seem that the adrenal secretion is under nervous control. As to the relative importance of the two parts of the gland, Swale Vincent says that "the cortex from a morphological standpoint would seem to be the more important or essential element of the suprarenal gland, for it is always more abundant in amount than the medulla, and is universally present in all animals above the very lowest vertebrates, whereas the medulla appears to be absent in some orders of fishes. In the present state of our knowledge the medulla must undoubtedly be considered as the more important from a physiological standpoint."

The writer wishes to express grateful acknowledgment for the invaluable assistance derived from the perusal of the manuscript of Mr. Flint's very scholarly contribution to this subject. *Emma E. Walker.*

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ADRENALS (PATH.). See *Addison's Disease*

ADRUE. See *Cyperus.*

ÆGLE MARMELOS. See *Bael Fruit.*

AEROTHERAPEUTICS, or PNEUMATOTHERAPEUTICS.—These terms refer to the employment of air as a therapeutic agent. They are generally restricted to the use of air that has been altered in density, by which it is possible to simulate the advantages derived from residence at high or low levels, and increase the functional power of the lungs. The term is sometimes broadened to include medicated air and air that has been altered chemically by increasing the proportion of oxygen, nitrogen, or carbonic acid gas. These latter, however, will be treated in separate articles and under *Inhalations.*

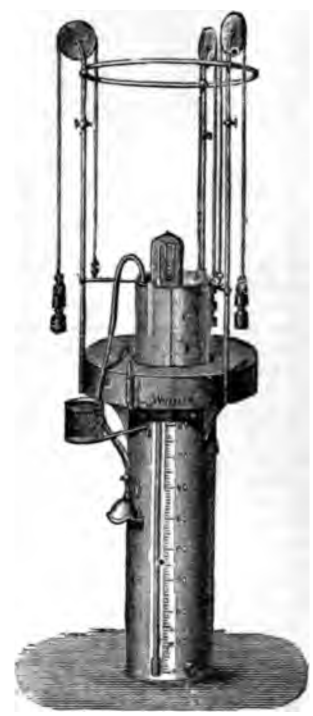

FIG. 50.—Waldenburg's Apparatus for Compressing Air. Natural height is one metre.

Two methods of adapting the air for use are in vogue. In one the patient is placed in a specially prepared chamber in which the density of the air may be increased or diminished; in the other the patient remains under ordinary atmospheric conditions, and inhales through a tube air that has been altered in density.

The pneumatic chamber, as used in the European sanitaria, is an elaborate and costly apparatus. It consists of a large metal, air-tight chamber, capable of seating three or four persons, in which the patient remains for a definite time. The arrangements are such that the air may be slowly or rapidly increased or lessened in density. There are provisions for heating and ventilating, windows through which the patient may be observed during treatment, and electric bells for the convenience of the patient. These chambers are numerous in Europe, and one has been erected at the Brompton Hospital for Consumptives, in London, England.

When the patient is placed in the pneumatic cabinet, the effect of the altered density is directed externally to the surface of the body and internally upon the lungs. The result is much the same as when the patient ascends to a high elevation or descends into a deep mine or in a diving-bell. To prevent the ill effects of a sudden change in pressure, the treatment is commenced under ordinary atmospheric conditions, then the alteration in density is made gradually, and the return to a normal pressure is equally slow. The importance of this has been noted by those in charge of men working in caissons during the construction of large bridges, where all the most distressing symptoms were traced to the workmen who too hastily emerged from the compressed air.

Air in which the density is increased is the form gen-

erally employed for therapeutic purposes. The increase is never very great, ranging from one-fifth to one-half of an atmosphere. This degree of compression is free from any danger. In the construction of the St. Louis bridge workmen continued their employment for hours under a pressure of fifty pounds, and others during the construction of the Brooklyn bridge were exposed to thirty-eight pounds, equal to about two and a half atmospheres.

FIG. 51.—Biedert's Apparatus.

The duration of the compressed air bath varies from half an hour to two hours, the first exposures always being of short duration. About one-fourth of the time is occupied in increasing the density and the same period in its reduction. The first effect of the increased pressure is to drive the blood from the surface of the body, and from the lungs, to the deeper organs and tissues. Later, the equilibrium is re-established, the peripheral circulation being increased and the congestion of the deep organs reduced. The respirations become fewer, but are increased in depth, and the chest walls become more mobile. The quantity of oxygen conveyed to the lungs is increased, as is also the amount absorbed by the blood; tissue change becomes more active, and at the same time the kidneys and other organs increase in activity. Although the patient exposed to compressed air derives a certain benefit from the dilatation of the lung tissue and other mechanical effects, its chief value depends upon the increased functional activity of the lungs and the improved tissue change that follows. All forms of congestion are improved, and exudates and other products of inflammation are removed. It is said to be of benefit in early lung congestion, bronchitis, pleuritic effusion, liver disease, and disturbances of other organs accompanied by hyperæmia. In anæmia and chlorosis it is of equal benefit.

FIG. 53.—Solis-Cohen's Apparatus for Inhaling Compressed Air and Exhaling into Rarefied Air.

Rarefied air in the pneumatic cabinet is employed to a much more limited extent as a therapeutic agent. It does not in any way supply the benefits of residence in high situations. Muscular action of the respiratory muscles, it is true, is increased during respiration, and the patient derives whatever benefit is to be gained from this form of exercise, but the air respired has not the purity or the chemical properties of mountain air, nor does the patient gain the general beneficial effect of living in mountainous regions.

In this country the pneumatic chamber has not received the attention that its importance would appear to warrant. This in a great measure is due to the expense necessary to equip and maintain one in proper order, but what will always hinder its adoption is the success which has attended the employment of the smaller apparatus for inhaling compressed or rarefied air.

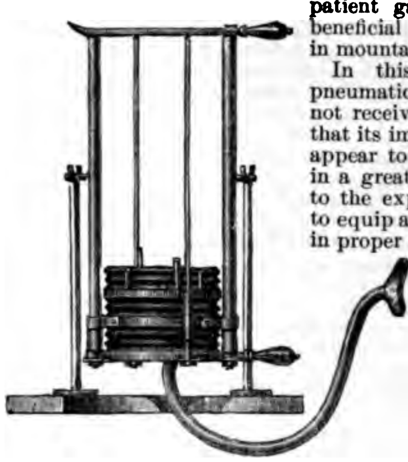

FIG. 52.—The Same, Reversed.

This method, which has been termed "pneumatic differentiation," is now adopted very extensively and possesses many advantages over the large chamber. The chief of these is the much greater expansive power of compressed air taken into the lung when the external pressure is that of the ordinary atmosphere. Equally advantageous are the numerous changes that may be made with the compressed air and the rarefied air. The patient may inspire compressed air and expire into the compressed air, or into ordinary atmosphere, or into a second vessel in which the air is rarefied. He may also reverse the order and inspire rarefied air and expire into any media.

A great number of appliances for carrying out this method of inhalation have been made, some of them being extremely complicated. Two principles prevail in their construction. In one the ordinary gasometer is the guide, in the other it is a bellows or an accordion. The best

Aerotherapeutics.

examples of these two systems are the instruments known as Waldenburg's and Biedert's.

In Waldenburg's apparatus the alteration in the density of the air is controlled by a system of weights and pulleys. There is also attached a gauge to indicate the degree of compression. Biedert's apparatus is constructed like an accordion and is suspended by a bar at its centre upon which it may be rotated. The tube for inhalation is attached at one end and the weights at the other. When the weight is uppermost the air in the apparatus is compressed; when the instrument is reversed and the weights are below, the chamber is expanded and the air becomes rarefied.

Prof. Solomon Solis-Cohen, who has done much to make known in this country the value of compressed air, has devised an instrument that is much superior in every respect ("Hare's Therapeutics," 1891, vol. i., 796). It is a modified Waldenburg gasometer, with a bellows attached, which is worked by the foot of the physician. The bellows maintains a constant supply of fresh air, and the combination of the two systems allows a reduction to be made in the size of the cylinder. The instrument is small and compact, and may be conveyed to the house of the patient without any inconvenience. He has also arranged twin cylinders (Fig. 54), in one of which the air is compressed and in the other rarefied; to this is attached an ingenious inhaler by means of which the patient may inspire from one cylinder and expire into the other without removing the mask from the face. For hospitals and large institutions a system of cylinders may be arranged for a number of patients to receive treatment at the same time, the pressure being derived from the ordinary water-supply pipe.

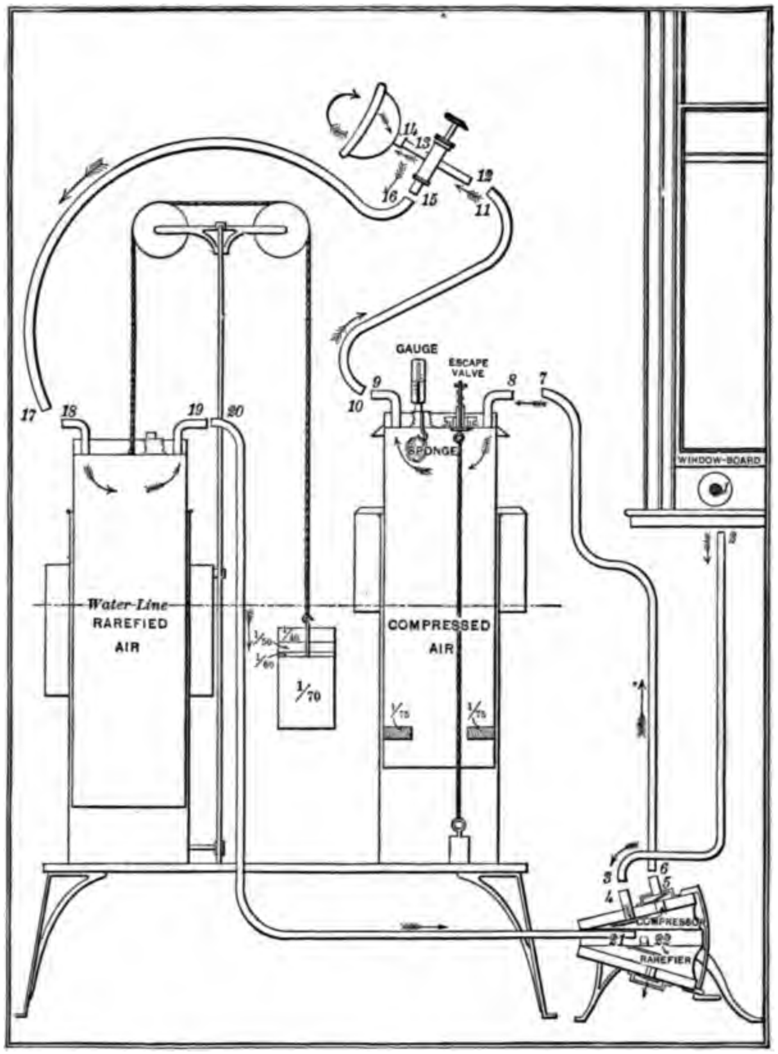

FIG. 54.—Section of the Same. Figures and arrows indicate the course of the current of air.

A small-sized pneumatic cabinet has been used by Drs. Martin and Johnson (New York *Medical Journal*, May 15, 1886). In this the patient is placed, and while the pressure in the cabinet is changed, he inhales, through a tube, air of a different density. The pressure in the cabinet is very easily controlled, and by means of a lever it may be increased or diminished with the respirations of the patient, aiding the expansion of the chest walls during inspiration, and compressing them during expiration.

The inspiration of compressed air is performed with ease, and the chest walls are expanded in a marked degree. The quantity of air in the lungs is greatly increased, and during expansion of the chest the alveoli and air cells are distended. The expiration is equally free, the rebound of the elastic structures forcing out a large proportion of air. If the expiration is into rarefied air, that remaining in the lungs is much less than the normal; and if the breathing is continued, it increases the flow of tidal and complemental air, and lessens the proportion of residual air. The distention of lung tissue extends to cells that have been rendered weak by disuse and to others that have been disabled by disease. On the former the effect is always beneficial, but upon the latter the advantage is not so certain. In many cases it restores to functional activity cells that have been blocked by secretions, but in others it may render active disease that is quiescent and improving. Upon the circulation, the effect is to increase the blood pressure and to render the flow of blood through the organs more rapid. The increased supply of oxygen also improves the quality of the blood. The physical effects are more or less modified by the media into which the patient expires. If the air is returned against the compressed air, an expiratory effort is required, during which many muscles are brought into action, and the elasticity of the lung tissue is exercised. If the medium into which the lungs empty themselves is other than the compressed air, the muscular effort is less, but the contraction of the lung tissue is much greater than under ordinary conditions. The value of these changes as a gymnastic exercise is very evident, as it adds to the vital capacity and increases the functional activity of the lung.

In pneumatic differentiation as in the pneumatic cabinet, compressed air is the form generally employed, the object being to increase the amount of air carried to the lungs. Rarefied air is of greater service as a gymnastic agent. During its use the lungs are filled only by a muscular effort; if the patient has sufficient muscular power to secure the larger amount of air required, the effect is beneficial; if not, the supply of oxygen is deficient and the evil results that follow are quickly manifest.

Aerotherapy is chiefly of value in all forms of hyperæmia and congestion of organs, and in anæmias and cachexias.

In phthisis the earlier it is employed the greater will be the advantages derived from its use. Its proper rôle is that of a prophylactic, and in the treatment of the earliest stages, as during these periods the action of the lung is diminished and the areas of congestion are only beginning. It should not be employed during acute inflammation, nor when the morbid process is approaching the stage of softening. If there is any tendency to hemorrhage it should not be used. The contraindication to its use in these conditions arises from the disturbance to which the affected areas are subjected, at a time when nature calls for rest, with a hope of cure. In pleurisy with effusion, absorption may be accelerated; and at the termination of empyema, when the chest wall is contracting, it is a most rational treatment to overcome or prevent the consequent deformity.

In all conditions in which the blood is anæmic and the various organs are deficient in action, it forms a valuable adjunct to massage, baths, and other hygienic measures. It rapidly improves the character of the blood and promotes tissue change, which with proper medicinal treatment will lead to the most satisfactory results.

The increased blood pressure that follows its use requires it to be employed with much caution in all forms of cardiac and renal disease, in which there are any degenerative changes in the vessels.

The density of the air required in this form of aerotherapy is very much less than that to which the patient is submitted in the pneumatic chamber. Instead of ranging from one-fifth to one-half of an atmosphere, it should vary from one-eightieth to one-thirtieth of an atmosphere. This difference is determined by the greater expansive force of the compressed air, when the external pressure on the thoracic walls is not increased. The inhalations should be taken regularly twice and even three times a day, and should continue for from half an hour to one hour. Solis-Cohen recommends the patient to inhale for ten minutes and then to rest for the same space of time. The inspirations should be made standing, if possible; they should be slow and deliberate, and everything should be done to facilitate the expansion of the lung.

Beaumont Small.

AEROTONOMETER. See *Respiration.*

AEROZOL. — A proprietary remedy representing twenty-five volumes of ozone dissolved in certain volatile oils.

W. A. Bastedo.

ÆSTHESIOMETER.—The word æsthesiometer is derived from the Greek αἰσθάνομαι, I perceive, αἴσθησις, perception, sensation, and μέτρον, a measure; thus meaning literally a measure of sensation; and it is used to denote an instrument which measures that form of sensation known as tactile sensibility (*Tastsinn* in German).

Tactile sensibility or the sensations of tactile impressions may be considered as comprising the sensations of touch, of locality or position (*Raumsinn, Ortsinn*, in German), and of temperature. The sense of touch is in this sense nothing more than a sense of pressure applied to the skin. These sensations differ in certain important respects from the *general* or *common sensations*, which include pain, sensual pleasure, and perhaps hunger and thirst.

Æsthesiometers, properly so called, are instruments for testing the sense of locality. The first one used, one which under slight modifications still retains its place, is that of E. H. Weber, who, in 1829, appears to have published his first account of his investigations in regard to the sense of locality. The instrument had probably, however, been for some time in use at that date, for in 1846 he refers to its use twenty years ago. It consisted simply of a pair of compasses with cylindrical arms, the points of which were so ground down that their ends had a diameter of one-third line, so that they should produce simply a sensation of touch and should avoid any sensation of pain. To use this instrument it was only necessary to place the two points upon the skin of the person to be examined, care being taken at the same time that he should not see whether both points or only one touched his skin, and by examination to find out at what distance from each other it was necessary that the points should be in order that they should be distinctly felt as separate. For in any portion of the skin two distinct points, if placed near enough together, will be felt as only one.

Weber found that the sense of locality, that is, the distance at which the points could be distinguished as two, varied much in healthy individuals in different parts of the body, and varied also somewhat, especially on the limbs, according to the direction in which the points were placed, whether longitudinally, obliquely, or transversely. His figures and those of Valentin for the normal distance between two points, which can be distinguished as such in the various parts of the body, are as follows:

TABLE OF VARIATIONS OF THE SENSE OF LOCALITY IN DIFFERENT PORTIONS OF THE SKIN (WEBER AND VALENTIN).

[The subjoined table gives the mean minimum distances (in Paris lines) for different parts of the body between the points of the æsthesiometer at which two impressions can be distinguished when the points are applied simultaneously. The first column gives the results of the experiments of Weber, the second of those of Valentin, while the third column (also from Valentin) gives the relative obtuseness of each portion of the body, the most delicate part, the tip of the tongue, being taken as the unit of measurement.]

Part of Surface.	WEBER.	VALENTIN. Mean.	VALENTIN. Relative obtuseness.
Tip of tongue	0.50	0.483	1.000
Palmar surface, third phalanx of forefinger	1.00	0.603	1.248
Palmar surface, third phalanx of middle finger	1.00	0.706	1.462
Palmar surface, third phalanx of ring finger	1.00	0.723	1.497
Palmar surface, third phalanx of thumb	1.00	0.725	1.501
Palmar surface, third phalanx of little finger	1.00	0.733	1.518
Red surface of under lip	2.00	1.500	3.106
Red surface of upper lip	2.00	1.520	3.147
Palmar surface, second phalanges of fingers	2.00	1.558	3.226
Palmar surface, first phalanges of fingers	.....	1.650	3.416
Dorsum of tongue (one inch from tip, Weber)	4.00	1.916	3.967
Dorsal surface, third phalanges of fingers	3.00	2.125	4.400
Portion of lips not red	4.00	2.208	4.572
Tip of nose	3.00	2.250	4.658
Edge of tongue, one inch from tip	.....	2.478	5.130
Palmar surface of the metacarpus (capitula ossium)	3.00	2.625	5.434
Lateral surface of dorsum of tongue	.....	2.500	5.176
End of great toe (plantar side of last joint, Weber)	5.00	3.250	6.729
Metacarpal joint of thumb	4.00	3.333	6.901
External surface of eyelids	5.00	3.833	7.936
Palm of hand	5.00	3.833	7.936
Dorsal surface of second phalanx of thumb	5.00	3.893	8.660
Dorsal surface of second phalanx of forefinger	5.00	3.893	8.060
Dorsal surface of second phalanx of middle finger	5.00	3.900	8.075
Dorsal surface of second phalanx of little finger	5.00	3.943	8.163
Dorsal surface of second phalanx of ring finger	5.00	3.971	8.221
Centre of hard palate	6.00	4.042	8.369
Mucous membrane of lips near gums	9.00	4.125	8.540
Skin of cheek over buccinator	5.00	4.541	9.402
Skin of cheek over anterior part of malar bone	7.00	4.620	9.565
Dorsal surface, first phalanges of fingers	7.00	4.917	10.180
Prepuce	.....	5.100	10.559
Dorsal surface of heads of metacarpal bones	8.00	5.250	10.869
Cheek, over posterior part of malar bone	10.00	5.286	10.944
Plantar surface of first metatarsal	7.00	5.875	12.164
Lower part of forehead	10.00	6.000	12.422
Back of hand	14.00	6.966	14.423
Lower part of hairy scalp in occipital region	12.00	8.292	17.168
Surface of throat beneath lower jaw	15.00	8.292	17.168
Back of heel	10.00	9.000	18.634
Pubes	.....	9.200	19.048
Crown of head	15.00	9.583	19.840
Patella and surrounding parts	16.00	10.208	21.135
Areola around nipple	.....	12.066	24.982
Dorsum of foot, near toes	18.00	12.525	25.932
Axilla	.....	13.000	26.915
Skin of forearm (upper and lower extremities of forearm, Weber)	18.00	13.292	27.520
Back of neck (over spinal column, Weber)	24.00	13.292	27.520
Upper and lower extremities of lower leg	18.00	13.708	28.381
Penis	18.00	13.850	28.675

Part of Surface.	Weber.	Valentin.	
		Mean.	Relative obtuseness.
Acromion and upper part of arm	18.00	13.886	28.708
Sacral region	18.00	14.958	30.969
Sternum	20.00	15.875	32.867
Gluteal region	18.00	16.625	34.420
Middle of arm	30.00	17.083	35.368
Middle of thigh	30.00	17.633	36.507
Spine near middle of cervical vertebræ	30.00	18.542	38.389
Spine near fifth dorsal vertebra	24.00	19.000	39.337
Lower part of thorax, and over lumbar vertebræ	24.00	19.912	41.225
Middle of dorsal vertebræ	30.00	24.208	50.120

Foster gives the following figures in millimetres obtained by the use of a pair of compasses (a Paris line equals 2.256 mm.):

Tip of tongue	1.1 mm.
Palmar surface of terminal phalanx of finger	2.2 "
Palmar surface of second phalanx of finger	4.4 "
Tip of nose	6.6 "
White part of lips	8.8 "
Back of second phalanx of finger	11.1 "
Skin over malar bone	15.4 "
Back of hand	29.8 "
Forearm	39.6 "
Sternum	44.0 "
Back	66.0 "

Weber's æsthesiometer is still in constant use, and serves its purpose well, but certain other forms or modifications have been introduced. In 1858 Sieveking published the account of his æsthesiometer in the *British and Foreign Medico-Chirurgical Review*. The principle is the same as that of Weber's, but the form is somewhat altered. Instead of using the common compasses Sieveking has made his instrument in the form of the beam-compass used by mechanics; that is to say, of a solid graduated bar of metal, which terminates at one end in a point running at right angles to the bar, while on the bar slides another point of horn or ivory, which can be fixed at any desired distance from the first by means of a screw on top. A modification of Sieveking's æsthesiometer has been made by Brown-Séquard, who has apparently made both the bar itself and the points lighter, and has done away with the screw at the top of the movable point. In his instrument the points are of steel, and there is a roughened prominence on the side of the second point to enable it to be readily moved by the finger or thumb (see Fig. 55). Nearly all the æsthesiometers at

FIG. 55.—Brown-Séquard's Æsthesiometer (reduced in size).

present used are modifications of these two forms. Hammond's convenient little instrument is a modification of Weber's, consisting essentially in allowing the index bar to swing on a rivet fastened to one arm of the compass, the bar, while in use, being held by a catch on the other arm, in which it slides freely. When not in use, it can be lifted from the catch and swings into approximation with the arm to which it is fastened, so that the whole instrument, when closed, occupies but little space and can readily be carried in the pocket. Carroll's instrument is simply a compass, each arm of which ends in two points, one blunt and one sharp, either of which can be used as desired; while Vance's is an arrangement of compass with flattened arms, which shuts up in a case like a penknife.

The delicacy of the sensation of space in various parts of the skin may be tested by the æsthesiometer in two ways. In the first place, as mentioned above, by determining how far apart the points must be placed in order to be felt distinctly as two separate points in any part of the skin; and, secondly, by fixing the points of the æsthesiometer at a certain distance apart and moving the instrument from one portion of the body to another. Thus it is found that the distance of the two points appears to increase when the æsthesiometer is drawn from the cheek horizontally over the mouth, one point resting on each lip, to the median line, and that if continued across that line to the other cheek, the distance appears proportionately to diminish. This method of testing with the æsthesiometer is, however, of no practical use, as we have no means of measuring the strength of our sensations.

From the numerous experiments made in regard to the normal tactile sensibility the following results have been deduced: 1. The points of the æsthesiometer always seem to be farther apart when one point is placed on one side of a natural opening and one on the other. Thus, when one point is placed on the upper lip and one on the lower, they appear farther separated than if both points are placed in a corresponding position on either lip. This in part accounts for the increase apparent when the æsthesiometer is moved from the cheek to the median line in Weber's experiment. 2. Other things being equal, the points of the æsthesiometer seem farther apart when they rest upon different tissues. Thus, for example, when one point is placed upon the mucous membrane of the lip and one point upon the skin, they seem farther apart than when both points are upon either the skin or the mucous membrane. 3. As a rule the points seem farther apart when they are on different sides of the median line than they do in corresponding positions when both are on the same side. This law does not, however, always hold good. 4. The direction in which the points are placed in relation to each other is of considerable importance in certain parts of the body, especially on the limbs. When placed transversely they appear to be at a greater distance from each other than when placed longitudinally. On the body proper there seems to be but little difference, while it is more marked on the face, and more so still on the limbs, especially the lower arms and legs. The cause of this is as yet unknown, but it may be that the skin over different muscles responds more readily to two stimulations than the skin over the same muscle when touched at two equally distant points. (According to Vierordt the relative delicacy of the sense of locality at any point on the skin of a special portion of the body, as compared to that of the other points of the same portion, is a function of its mobility, and increases proportionately to its distance from the axis on which that part moves, since it depends on the relative greatness of the excursions which it effects about its axis through the movements of the part concerned.)

In applying the æsthesiometer certain precautions should always be observed. In the first place, the operator should take especial care that both points are applied as nearly as possible *simultaneously*, as the element of time enters distinctly into our tactile impressions, and the greater the time which elapses between any two impressions of a similar kind, the more readily are such impressions recognized as distinct. For this reason, also, the points, when once applied, should not be moved, for if they be moved, a new sensation, or a series of sensations, will be produced, which will enable us to interpret the impressions more easily. It is a curious fact that, if two points be placed so near together that they are felt as only one, and a third point be drawn across the skin between the two, the sensation of a moving object can be felt, although its position cannot be localized. The impression produced by the points, moreover, becomes clearer the longer they remain in contact with the skin. Hence, in making comparative observations, the points should be held on each place for the same amount of time. In addition to the simultaneousness of the touch the pressure at the two points should be as nearly equal

as possible and as slight as possible. As we shall hereafter see, the ratio of the sense of pressure in different parts of the body varies considerably from that of locality, and the two different sensations should be carefully distinguished. For practical purposes, however, the amount of pressure exercised in ordinary cases when due care is taken is not sufficient to affect in any way the result. It is otherwise, however, when a different amount of pressure is exerted on the two points. The force of the stimulus produced at one point is liable so to act that the stimulus produced at the other is perceived but indistinctly or not at all. A third and obvious precaution to be observed in using the æsthesiometer, when testing corresponding portions of the body, is that the points should in each case be placed in the same direction, that is, longitudinally, obliquely, or transversely, as may be, and that they should be on exactly corresponding parts and at an equal distance from the median line. This is of especial importance in pathological cases, where the æsthesiometer is used for the purpose of diagnosis.

In an examination for physiological purposes we must also take into consideration the mental condition of the subject. Whenever the attention is strongly fixed upon any point in the body, sensations produced there by external objects are more readily and more quickly perceived than when the mind is occupied by other thoughts. Hence, when the attention is fixed upon the action of the æsthesiometer, the points will be perceived more readily and more distinctly than would otherwise be the case. The readiness with which the points are perceived and their position determined varies also greatly with practice. Cold diminishes the tactile sensibility, as does also extreme heat. Hyperæmia, as well as anæmia, probably likewise diminishes it.

BARÆSTHESIOMETER.

The term baræsthesiometer, from βάρος, weight, and æsthesiometer, has been applied to instruments which are used to determine the delicacy of the cutaneous sense of pressure.

The first attempts to measure the cutaneous sense of pressure were made by E. H. Weber, who for this purpose used weights laid directly upon the parts to be tested, the muscular sense being excluded by firmly sup-

FIG. 56. — Eulenburg's Baræsthesiometer. Front view.

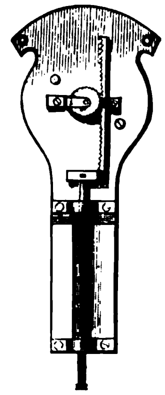

FIG. 57.—Back View of the Same Instrument.

porting the part to be examined upon some solid body. Various weights, as nearly as possible of the same size and same temperature, were applied in succession to the part, and the smallest difference which could be thus detected was carefully determined for each part. Weber himself made use for this purpose of coins (thalers) which he laid upon the forehead, the head being supported, and thus he obtained some important results. According to his researches, the sense of pressure varies much less in the different parts of the body than the sense of locality, and does not vary in the same proportion in the different parts. In the place of coins Kammler and Aubert made use of small discs of cork or elder-pith, on which weights could be placed, while Dohrn estimated the sense of pressure by means of a blunt point attached to the arm of a pair of scales. In 1868 Goltz published the account of his apparatus, by means of which he sought to determine the smallest *rhythmical* pressure which can be perceived on any given part. For this purpose he made use of an india-rubber tube, both ends of which were closed and which was rendered tense by being filled with water. The pulsations produced by the experimenter at one end of the tube were transmitted to the other end, which was laid upon the part to be tested. Goltz's results corresponded with those of Weber for the *sense of locality*, except that the tip of the tongue was found to be proportionately much less sensitive to pressure.

To determine the delicacy of the sense of *variation of pressure*, Eulenburg used the baræsthesiometer which bears his name (Fig. 56). It consists simply of a hard-rubber plate, on to which is screwed a spiral spring through whose greater or less tension a stronger or weaker pressure can be exerted on the plate. This spring is placed inside a case, and can be more or less compressed at will by means of a guiding rod. Through a toothed wheel, which is placed in connection with this rod, an index is set in motion, which marks on a dial plate the amount of tension of the spring, thus showing the strength of the pressure exerted. Each figure on the dial corresponds to a pressure of 1 gm. Eulenburg found that the sensibility to variations of pressure was most delicate on the face, especially the forehead, then on the lips, the back of the tongue, cheeks and temples. Here it is $\frac{1}{30}$, often $\frac{1}{40}$. On the upper extremities it is $\frac{1}{20}$ to $\frac{1}{10}$, and does not vary much in the different parts. In the lower extremities the anterior portions of the lower leg and thigh seem to possess the greatest sensibility; next follow the back of the foot and dorsal surface of the toes, while on the plantar surface of the toes, the sole of the foot, and the posterior portions of the lower leg and thigh the sensibility is much weaker. Löwitt and Biedermann found that by the finger tips the differences between weights which bear to each other the proportion of 29 to 30, could be appreciated, provided the weights were not too light nor too heavy. The power of determining variations of pressure varies in accordance with the amount of the pressure. Except perhaps for minimal pressures, the greater the initial pressure the greater must be the increase of pressure in order that a variation may be felt.

THERMÆSTHESIOMETER.

For measuring the sensibility to differences of temperature, Weber used two long glass phials filled with oil, into each of which he introduced a thermometer, passing it through the stopper. By means of this apparatus he found that the skin of the face was the most sensitive, especially that of the eyelids and cheeks. The lips, on the contrary, which are more sensitive to sensations of place, are less so to those of temperature. Moreover, the sense of temperature, as tested in this way, instead of being greatest in the middle of the lips, is greater on the lateral portions of the upper lip, greatest on the cheeks, and less as we approach the median line. In 1866, Eulenburg described his thermæsthesiometer. The instrument consisted simply of a "frame" and two thermometers thereto attached. For "frame" he made use of Sieveking's æsthesiometer, to the bar of which he fastened two exactly similar thermometers which corresponded accurately to each other. Their lower ends were drawn into broad glass bulbs, and flattened at the bottom so as to rest readily upon the skin. These thermometers worked like the points of the æsthesiometer, one of them being fixed at the end of the bar, while the

other could be moved along it as desired, and be fastened at any distance by means of a screw. Thus the distance between the thermometers was determinable at will, and could be estimated by a scale marked on the bar. In using this apparatus, one thermometer was heated or cooled as desired, while the other was left at the temperature of the room. In the following year, 1867, Nothnagel published a series of very careful investigations into the cutaneous sensibility of the temperature, in making which he used a special instrument. Nothnagel's thermæsthesiometer consists of two exactly similar cylindrical vessels, two and a half inches high and one and a half inches in diameter. Their walls are made of wood and are double, some poorly conducting substance, as ashes, being placed between the two parts. The bottom is formed of copper, a good heat conductor. On the top of the vessel is a tightly closing wooden cover which moves on a hinge, and which has an opening on one side. Corresponding to this opening there rises perpendicularly from the edge of the vessel a piece of wood to which are fastened two rings. Through these rings and through the opening in the cover a thermometer is thrust into each vessel, which is partially filled with water, whose temperature may readily be rendered different in the two vessels by plunging into it some good conductor, which has been previously heated or cooled. The vessels should be placed rapidly one after the other on the part to be examined, and the time of contact should last until the subject has formed a judgment in regard to the temperature. Care must be taken that the whole surface of the bottom of both vessels should rest against the skin, since, as is well known, the strength of the impression and the delicacy of the sensibility to temperature grow with the increase in the number of nerve ends affected. By this means Nothnagel determined that the greatest capacity for distinguishing differences of temperature exists when the temperature is between 27° and 33° C.; up to 39° C. it is but slightly diminished, but from thence to 49° C. it diminishes rapidly, and at the latter point pain occurs. From 27° to 14° C. the capacity diminishes in much the same ratio as from 33° to 39° C., but between 14° and 7° C. it falls off rapidly. He found that in different parts of the body the following differences in temperature could be distinguished:

	Centigrade.
Sternum	0.6°
Chest, upper and outer portion	0.4°
Epigastrium	0.5°
Abdomen, upper lateral portion	0.4°
Middle part of back	1.2°
Lateral portions of back	0.9°
Palm of the hand	0.5°-0.4°
Back of hand	0.3°
Forearm—extensors	0.2°
Forearm—flexors	0.2°
Upper arm—extensors and flexors	0.2°
Dorsal surface of foot	0.5°-0.4°
Lower leg—extensors	0.7°
Lower leg—flexors (calf)	0.6°
Thigh extensors and flexors	0.5°
Cheeks	0.4°-0.2°
Temples	0.4°-0.3°

The sensibility to variations of temperature seems duller as we approach the median line. The hand and fingers are generally alike, the lower arm more sensitive than the hand, and the upper arm more so than the lower arm. By extremes of heat or cold a thermanæsthesia is produced. Anæmia increases sensibility to temperature, hyperæmia is said to diminish it.

Kronecker's thermæsthesiometer resembles Eulenburg's, but the latter's thermometers are replaced by metal tubes, each divided nearly to the end by a partition, as in a double-irrigating catheter. Through these water of a fixed temperature can be caused to flow.

Goldscheider studied the topography of the temperature sense by means of warm and cold metal cylinders with a round contact surface 1 cm. in diameter. He also used in other experiments a metal globe which could be heated or cooled.

William N. Bullard.

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ÆTIOLOGY. See *Infectious Diseases.*

ÆTNA SPRINGS.—Napa County, California.

LOCATION.—At the upper end of Pape Valley, sixteen miles northeast of St. Helena.

ACCESS.—By rail via Napa to St. Helena, and thence by stage over a well-graded, picturesque road. Hotels and cottages.

This resort is delightfully situated at an elevation of 1,000 feet above the Pacific, in the midst of wild mountain surroundings. The mountains are well stocked with game, and the streams afford good fishing. There are a number of excellent springs in the neighborhood, those used for drinking purposes having a temperature of 98° F., while those employed for bathing show a temperature of 106° F. The following analysis was made by Dr. Winslow Anderson in 1888:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	28.75
Sodium carbonate	78.06
Sodium sulphate	8.92
Potassium sulphate	0.56
Potassium carbonate	13.23
Magnesium sulphate	0.45
Calcium carbonate	8.94
Ferrous carbonate	0.05
Silica	0.09
Organic matter	Trace.
Total	134.05

Carbonic acid gas, 63 cubic inches.

The water is sparkling and invigorating, and possesses a decided tonic influence as well as slight aperient properties. It is a good type of alkaline-saline-carbonate water and, as will be observed, resembles the waters of Ems to quite a marked extent. This water is increasing in favor on the coast, and has already acquired considerable reputation in renal diseases. Good results have also been reported in cases of rheumatism and neuralgia as well as in those of dyspepsia, torpidity of the bowels, hepatic disorders, and uterine disease.

Several other springs whose waters have not been fully analyzed are found close by. They contain more iron than those above mentioned, and are known as the "Iron Soda" Springs. They are much resorted to for anæmia and wasting affections.

James K. Crook.

AGAR-AGAR.—The name of a large number of East Indian sea weeds which are used in the manufacture of "vegetable gelatin"; also the name of this gelatin. The general nature of these substances is similar to that of chondrus, or Irish moss. It is one of these species which yields the material for the Chinese "bird's-nest pudding." Agar-agar is manufactured chiefly in China, the sea weeds being sent there from other countries for this purpose. It is, however, more or less manufactured in other countries also, especially in Japan, and it is the latter variety which is chiefly used for bacterial cultures. In the country of its production, agar-agar is very largely used for food, both alone and as an ingredient of jellies. It is also very largely employed as a sizing in silk manufacturing. It occurs in thin, transparent, colorless sheets, a great many bound together, or as bundles of long shreds, or in the form of irregularly

square sticks, nearly a foot long. The latter form is that generally used in bacteriological work. It is less transparent than either of the others, and is not so white.

Agar-agar consists almost wholly of gelose, a substance the solution of which cools to a jelly, which is much more stable than that of gelatin, requiring a higher temperature for melting. It is said that a solution of 1:500 of water will yield a stiff jelly. Gelose is precipitated by alcohol, but not by tannin.

Gelasine is merely a variety of agar-agar.

Agar-agar has no medicinal properties, its uses being wholly nutritive and mechanical.

H. H. Rusby.

AGARIC, PURGING.—(*White agaric; Touchwood, Spunk, Tinder.*) The decorticated hymenium of *Polyporus officinalis* Fries (*Boletus Laricis* Linn.); order, *Basidiomycetes, Hymenomycetes;* a large fungus growing upon the stems of the European larch and of one or two other conifers. It forms large hoof-shaped masses upon the sides of the trunks, and penetrates with its mycelium deep into the wood. When young they are soft and juicy, but when fully grown hard, and of a consistence between spongy and corky. The masses are collected in Europe, Asia Minor, etc., and usually prepared by drying and peeling. Agaric is in yellowish-white, friable, light, and spongy irregular balls and lumps, from the size of an orange to that of a cocoanut and larger. It has evidently been peeled, and the surface is finely rough and dusty with minute separated particles. The texture is rather firm, but soft; it can easily be reduced to a coarsish powder by friction or by rubbing on a sieve, but is difficult to pulverize finely; its microscopic structure—a tissue made up of interlacing, thread-like cells—explains its peculiar consistence.

Agaric has a heavy fungous odor, and a slowly developing, bitter, nauseous taste, which is at first sweetish. Its powder is very irritating to the eyes and nose, and produces violent sneezing. As it is also light and dusty, persons employed in beating it in mortars are obliged to resort to devices to prevent its rising.

It contains nearly one-third of its weight of resinous matters, extractible by strong alcohol, and these can be separated further into three or four simple resins. The active principle is *agaric* or *agaricic acid.* Commercial *agaricin* is a concentrated extract of agaric, and constitutes an impure and indefinite form of agaricic acid.

Agaric, as its name indicates, was originally used chiefly as a cathartic, but such use is rare at present. It is now rather considered that purgation is indicative of over-dosing. It is, in fact, but little employed in its own form, while agaricin and agaricic acid are growing in favor as remedies for the control of sweating, especially in phthisis. The dose of agaric is 0.02 to 0.06 gm. (gr. iij. to x.). More than this acts as a purgative. (See also *Agaricic Acid.*)

H. H. Rusby.

AGARICIC (or AGARICINIC) ACID.—($C_{16}H_{30}O_5 + H_2O$.) The active constituent of agaricin. It occurs as a white, almost tasteless powder, soluble in alcohol and with some difficulty in water, and may be given in doses of .02–.03 gm. (gr. $\frac{1}{3}$ to $\frac{1}{2}$), for the same purposes as those for which agaricin is used. (See *Agaric.*)

H. H. R.

AGATHIN.—Cosmin-salicyl-alpha-methyl-phenyl-hydrazone, $C_6H_4CH_3N_2.CH.CH.OH$. This compound results from the reaction between the basic alphamethylphenylhydrazin and salicylic aldehyde. It occurs in colorless crystals, or in greenish-white crystalline flakes; is odorless, tasteless, insoluble in water, and soluble in alcohol and ether. It was introduced by Roos as a remedy for rheumatism, and it has been found effective in this disease and in neuralgia. It has been known at times to produce headache, but not any of the other symptoms of salicylism. This is one of the rheumatism remedies which do not depress the heart. Dose: gr. iij. to x. from three to six times a day.

W. A. Bastedo.

AGE.—The age of a human being does not, as usually reckoned, correspond to the length of time it has existed, because the ordinary calculation starts from the date of birth, and excludes the preceding period of uterine existence. If we are to be strictly accurate, the age of any animal ought to be reckoned from the time of impregnation, especially if we are to compare different species one with another, in regard to the changes which correspond to successive ages. The act of impregnation creates a new individual, which alters as time elapses, and the liberation from the womb is only one of the alterations, one event, occurring in the life history of the individual; it is therefore artificial arbitrarily to select the date of delivery as the zero point from which to start the reckoning of the age, the more so as we know that the period of gestation varies very considerably in length, and that consequently the age of the child at birth is not by any means uniform. In the case of man it is the most convenient plan to adopt popular custom, because the ages as reckoned from birth are generally known with exactitude, but the age of the fœtus at birth is almost never known for a given individual. Indeed, we have at present no means of determining satisfactorily the age of a human embryo or fœtus, because we have no sufficient available data for ascertaining when impregnation takes place. As is shown in the articles *Fœtus* and *Impregnation,* there is always a possible error of several days in any estimate of the age of a fœtus, even when the history of the case is fully and accurately known, and there are decided reasons for thinking that there may be sometimes an error of a month or whole menstrual period. Obviously it is not practicable to calculate the age of man from an event the time of which we cannot know correctly, and it is the only practicable course for us to follow custom, and assume the commencement of life's journey to be some way along the route, namely, at birth; at least, whenever we have occasion to measure age.

From impregnation to death, at the natural term of life, the organism undergoes a definite series of changes which are termed the phenomena of senescence; in plain words, the organism grows old. The most important, if, indeed, not all the changes, may be grouped under three heads: First, the increase in the number of cells; second, the weight of the cells; and third, the differentiation of the tissues. The first and second are the essential factors of growth, and under *Growth* they are more fully discussed. Unfortunately, we have no knowledge as to the number of cells in the body at different ages, nor is it possible to make even a valid estimate. It appears entirely practicable for some patient investigator to make an approximate determination of the number of cells in the body; a trustworthy result would be extremely valuable. But though we cannot speak of actual numbers, we are able to say that the rate of multiplication of cells diminishes gradually with one or two possible interruptions in man. The demonstration of this law is given in the article on *Growth.* As regards the size of the cells, we know that at first the size is reduced; during the segmentation of the ovum, the amount of material remains nearly constant, while the segments (cells) multiply; hence they necessarily become smaller. During fœtal life they remain small, even after their differentiation into distinct tissues, but it is still uncertain how much of the growth of children is due to the mere increase in size of the histological elements and how much to the increase in their number. The difference between the fœtal and adult cells is readily seen; unfortunately, it is impossible to give a table of comparative measurements, for the micrometric data, even of the best authorities, are, with very rare exceptions, utterly worthless, from their extreme inaccuracy. The structure of the tissues varies according to the age; for each age there is a characteristic phase of development of the histological

elements, both in structure and arrangement; hence the general anatomy and, therefore, also the functions alter in correspondence with the age. Thus, in a philosophical view of the career of any organism, we are compelled to regard it as a function of the time elapsed since the procreation of the individual. It is important to insist upon this conception, because the student of human anatomy derives his notions almost exclusively from the study of the adult, and consequently fails to seize the idea that much of what he conceives to be essential and typical is only temporary.

There is another general consideration to be urged upon the attention of the reader: the older the organism the longer it requires to change. An infant alters more rapidly than a child, an adult more rapidly than an old person. This fact has a more profound significance than at first appears, because it not only suggests the only theory of the origin and nature of natural death having any serious value, but also is the clew to the distribution of variations in age. For the theory of death, see the concluding portion of the article on *Growth*. The law of variations to which we refer demands brief elucidation. Varieties occur in all degrees: with living organisms there is in each case a certain variety which occurs most frequently, and on either side of this most frequent type (geometrical mean) occur other varieties which are found to be less frequent the more they depart from the central type. On the doctrine of chances the distribution should be alike above and below the mean, provided always there is no predominating factor or factors of variation to disturb the symmetry. In the development of living organisms there is such a disturbance through the effects of age; a concrete example shows the phenomenon plainly. The following table, after Heinricius,* gives the ages and number of persons observed in 3,500 recorded cases of first menstruation in Finland. Below the table is given the graphic representation of the same data.

TABLE OF 3,500 CASES OF FIRST MENSTRUATION (observed by HEINRICIUS in Finland).

Ages (years)....	11	12	13	14	15	16	17	18	19	20	21	22	23	25	26
No. of Cases....	9	33	135	440	765	846	560	347	198	102	41	12	7	4	1

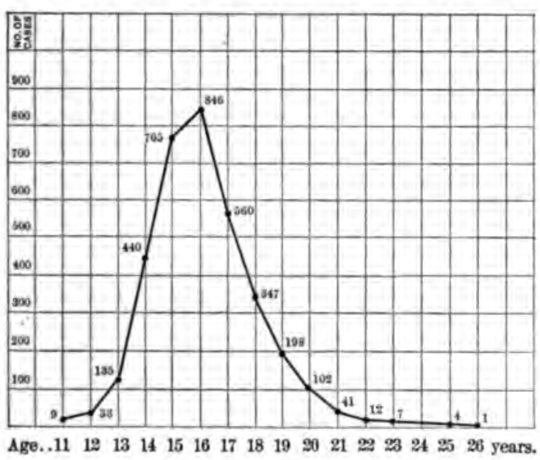

FIG. 58.

The curve shows that the year in which the first menstruation occurs most frequently is the sixteenth, and the further we follow the curve from the maximum, either forward or back, the lower it sinks. Moreover, from the maximum to the minimum is (probably) only seven years on the young side, but ten years on the old side. Here, then, we see that an equal range of variation covers a much shorter period of childhood than of later life. When a larger series of statistics are compiled, the difference in the premaximal and the postmaximal period is found to be considerably greater. This phenomenon occurs not only with menstruation, but with many, and probably all, or nearly all, phases of the development of the body; the time at which a given change takes place varies in different individuals, and, as far as at present known, always according to the law just indicated. In the article on *Growth* another set of facts are brought forward, demonstrating the same principle, which we may now formulate as follows: *The time required to accomplish a change of a given extent increases with the age of the organism.*

It is evident that this generalization needs to be tested with great thoroughness, especially to ascertain whether it is rigidly applicable in details, or only in regard to the whole course of development broadly considered. As no researches have heretofore been made to settle the alternative stated, it is very desirable that they should be undertaken. It may be discovered that diseases and recovery from diseases vary in rapidity in accordance with age, the rate of change decreasing with the age. This can be decided only by extensive statistics in regard to organic diseases. A large number of observations of the progress of fatal new formations—of cancer, for example—would be of high value. It is not to be anticipated that the diseases of a parasitic or zymotic character would exhibit necessarily any such correlation with age, because their course is dependent primarily on other causes than the condition of the organism in which they appear. If the rate of disease does vary with age, the desirability of knowing the fact is too obvious to require further emphasis; we can, therefore, only express the hope that some one having a proper opportunity will soon make an adequate investigation.

It is a common custom to divide the period of life into a succession of ages, but all such divisions are more or less arbitrary; and though extremely convenient, are quite without scientific significance. The ages commonly adopted are: (1) *Infancy*, from birth to the appearance of the temporary teeth; (2) *childhood*, from the cutting of the first permanent teeth to puberty; (3) *youth*, from puberty to the attainment of the full stature, that is, eighteen or nineteen for girls, twenty-one to twenty-two for boys; (4) *maturity*, covers the interval from youth to the climacteric, after which follows (5) the period of decline or *old age*. Another very common distinction is made between the period of development, say up to twenty-five or thirty years, and the period of decline; but, as is explained under *Growth*, there is a steady decline going on during the first period also. It would, perhaps, be more scientific to designate the earlier phase as the period of histogenesis, during which the tissues are being evolved, and the latter as the period of histolysis, in which the tissues are breaking down—degenerating. But, after all, though a great deal has been written and said, very seriously too, upon the division of life into ages, the discussions have never, and can never, lead to much result beyond fixing upon a set of arbitrary terms, which will always be convenient, provided they are left sufficiently vague.

The other matters which might be put under Age are to be found elsewhere, such as the determination of the age of a skeleton, the age at which the teeth are cut, etc. For the characteristics of infancy and childhood, anatomical and physiological, see the articles on these topics. For the changes in old age, see *Senility*.

Charles Sedgwick Minot.

AGENESIA, AGENESIS.—(German, *Agenesie*; French, *Agénésie*.) Without generation; without formation; without parents; unborn; undeveloped; possessing no sex. From the latter meaning arose the conception of sterility or impotence, and the early use of the term in medicine was restricted to this meaning. Later, the idea of lack of sexual appetite became included in this, and the word was used by French writers especially with the meaning of anaphrodisia rather than with that of impo-

* Centralblatt für Gynäkologie, 1883, vii., 72 to 73.

tence. The word has now entirely lost its early significance and has acquired the technical meaning of *total failure of development.*

A partial or imperfect development of parts whose embryonic foundations have been laid is not to be included in the significance of this term, but should be expressed by the words *aplasia, hypoplasia.*

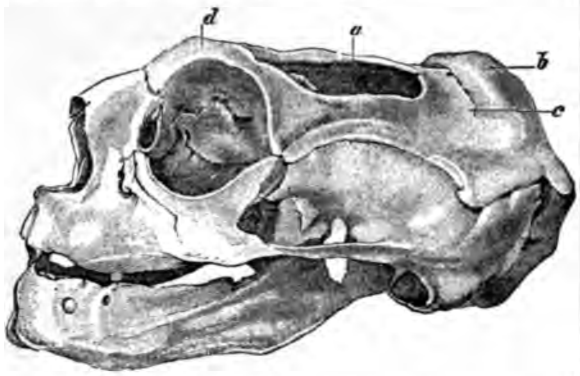

FIG. 59.—Partial Agenesia of the Bones of the Cranium in Anencephalia. *a*, Defect; *b*, occipital portion of skull; *c*, parietal bone; *d*, frontal bone. (Reduced one-fifth.) (Ziegler.)

There is, nevertheless, much diversity of use among writers as to the exact significance given to each one of these terms. Aplasia in its original sense means a failure of restoration or rebuilding, but is now used with two meanings: that of a numerical atrophy, and that of a partial failure of development. By some writers the three words are used synonymously with the meaning of either partial or entire failure of development. A few authors also use these terms with the significance of atrophy. The present tendency is strongly in the direction of giving to each word a distinct place in technical terminology; to atrophy, that of diminution in size after development; to aplasia and hypoplasia, that of imperfect development; to agenesia, that of total failure of growth or destruction of the part after it has begun to develop. Hypoplasia appears to have acquired the significance of a slight defect of growth; aplasia is used to indicate more important deficiencies.

The causes leading to imperfect development may operate at such an early period in fœtal life that organs or parts may entirely fail of development (agenesia), or later, before the completion of growth, so that the affected parts are not of normal size (aplasia, hypoplasia). Fœtal agenesias and aplasias play the chief rôle in the formation of monsters. The extra-uterine aplasias affecting the development after birth may lead to a reduction of size of the entire body or extremities, and to an imperfect development of the sexual apparatus.

Aplasia may affect the entire skeleton so that abnormally short individuals result (dwarfs), or the bones may be unsymmetrically developed (partial dwarfism). The bones of the head are very frequently affected, giving rise to the conditions known as microcephalus and micrencephalus. The central nervous system may show defective development, with or without changes in its bony covering; one of the hemispheres may be abnormally small or the entire brain may show a retarded growth. Next to those of the nervous system, aplasias of the genito-urinary tract are most common in occurrence. The uterus or the entire set of female generative organs, external and internal, may remain in an undeveloped state at puberty. The external organs of the male are also not rarely abnormally small, and in non-descent of the testicle aplasia of the organ usually takes place. Parts of the intestine may be so imperfectly formed as to consist of a narrow canal or a small fibrous cord; and in the development of the lungs the alveoli of portions of one or more lobes may be imperfectly developed. The kidney and liver may also suffer a greater or less imperfection of growth. Hypoplasias of the heart and vascular system have been thought to play an important part in the pathology of chlorosis and lymphatic struma.

Agenesia for the greater part leads to the production of monsters or to the development of malformations which may be of so serious a nature as to preclude the possibility of extra-uterine life. There may be absence of the cranium (acrania) (Fig. 59), or of the brain (anencephalus), or of the spinal cord (amyelia). A complete failure of development of any part of the skeleton may take place, or of any part of the nervous system. Agenesia may also result from the failure of developing centres to unite or of clefts to close; in the latter class are to be placed a great variety of malformations (cleft palate, hare lip, ecstrophy of the bladder, etc.). Agenesia of a single organ may also arise from the imperfect separation of two organs which develop from a single focus (cyclopia), or from the secondary union of two divided organs. Atresia of the mouth, nose, ear, anus, vagina, or urethra may also result from agenesic development of portions of these structures. Agenesia of the bones of the extremities, of single muscles or groups of muscles, of the auricular septum, etc., are among the more common malformations which permit of extra-uterine life.

The tissues composing aplastic organs may be normal in structure, but there is very frequently associated with abnormal smallness of the entire organ a deficient development of its elements or a complete absence of the more highly specialized ones. In aplasia of the central nervous system there may be agenesia of the ganglia cells and nerve fibres; portions of the brain may be represented by fibrous or membranous masses. The hypoplastic ovary may show complete agenesia of its ova; and in the lung there may be entire failure of development of the alveoli (Fig. 60). Likewise in the liver and kidney, portions of the secreting structures may fail entirely.

The causes of aplasia and agenesia may be either intrinsic or extrinsic.

As intrinsic causes may be considered all of those that arise in the germ either through inheritance or pathological germ variation, or through disturbances of the copulation of the sexual nuclei. The inheritance of agenesic malformations may be direct, atavistic, or collateral. Certain types of faulty development, notably those of the nervous system and genito-urinary tract, occur with a certain frequency in degenerative inheritance. The pathological germ variation may be the result of the union of two nuclei, one or both of which is abnormal, or of the union of two normal nuclei which are not suited to each other.

FIG. 60.—Agenesia of the Respiratory Parenchyma of the Left Lung. The lung consists of dense connective tissue in the midst of which dilated bronchi are found. (Horizontal section through the apex of the upper lobe. Natural size.) (Ziegler.)

But by far the chief causes of agenesia are extrinsic. Of these, pressure, jarrings, disturbances in the supply of oxygen and nutrition, contaminations of the maternal blood from intoxications and infections, fœtal inflammations, abnormal conditions of the amnion, play the most

important part. There is very strong evidence that a large proportion of agenesic malformations arise from abnormal adhesions between the embryo and the amnion, or to abnormal pressure exerted by the amnion upon the developing germ. The head and extremities suffer most frequently from these causes. Aplasia of the bones is sometimes associated with thyroid disease.

The agenesias of the more important structures of the body lead as a rule to the production of a non-viable fœtus. Only those failures of development affecting the body in such a degree that life processes are not seriously interfered with admit of living after birth. Dwarfism, agenesia of the bones or muscles of the extremities, many of the cleft malformations, agenesia of the sexual organs, etc., permit of life and extra-uterine growth. Some of these may be compensated for by hypertrophy of other organs or parts of the same organ, while others may be improved by surgical treatment.

Aldred Scott Warthin.

AGEUSTIA. See *Taste, Disorders of.*

AGORAPHOBIA.—A peculiar emotional neurosis in which morbid fear of being alone in an open space, or in analogous circumstances, is accompanied by the perfect consciousness that this fear is absurd, but with the absolute inability to overcome it.

As one of the psychic stigmata this state of neurasthenic anxiety or emotive obsession is the most frequent of the *phobias* and assumes the most varied forms. Although occurring in the blind, an attack may be produced by ideas of space, vastness, height, depth, eternity, or such kindred subjects. In certain degenerates these impulsive and emotional but groundless ideas show themselves in the deadly terror and anguish of *acrophobia, amaxiphobia, astrophobia, cremnophobia, hydrophobia, thalassophobia,* and *taphiphobia,* in all of which there are contradictoriness of sensory impression and inability to form an accurate conception of the surroundings.

SYMPTOMS.—Sudden weakness and muscular tremor render standing difficult. An attack may, however, be gradual. Tremor extends sometimes to the trunk, thence to the arm and lower jaw; sometimes a wavy sensation goes from the heart to the back of the neck. Chilly sensations in the back, stomach, breast, and limbs are followed by heat, redness of the face, profuse sweating, and violent palpitation. At the same time there is oppression and contraction of the pectoral muscles; the speech, abrupt and anxious, is sometimes momentarily impossible; intermittent pains, sharp, rapid, and fatiguing, following the trunks of the nerves, run along the legs, ascend the body, and extending to the arms, seem to lose themselves in the hollows of the hands; there is formication, with numbness in different parts of the body; festination is observed in some cases; in others emotional diarrhœa; and again sudden loss of motor power comes like a stroke of palsy, and the patient falls powerless with his face downward, in a state of waking nightmare.

But these physical troubles are only the outward and visible signs of the moral trouble that is the true primitive phenomenon and the cause of all the others. That which is pathognomonic and constitutes agoraphobia, is *terror,* up to its extreme degree, and consequent motor impotence. The single primitive phenomenon, as the name indicates, is *groundless fear.* Looking down a deep mountain gorge, hanging over the brink of a burning crater, crossing Niagara on a tight-rope, or falling from such a precipitous height as the Washington monument, are sensations less fearful and astonishing than those of an agoraphobe. This terror causes a patient to feel dumbfounded, thunderstruck, exhausted, and at the same time isolated from the entire world; space seems to extend to infinity under his feet; he feels persuaded that he will never accomplish a given journey; walk a certain distance without fainting; hold out for a certain time without food, or support existence for a certain period without fresh air. He experiences fear and want of self-confidence when in a crowd, at theatre, at church, or in a boat, omnibus, or railway car. An agoraphobe, unable to ride on a railway train without a brandy flask in the left hand and a Bible in the right, presumed that one counterbalanced the effects of the other. Fear to meet acquaintances; fear of spiders, mice, and snakes; fear of apoplexy and of death come over the patient like the fear that seizes a timid child in the dark; sensations like those of a swimmer deceived by false chances, or those of a victim to tantalizing hopes, cause the patient to be on the point of screaming or weeping, and he is, figuratively speaking, frozen with terror, motionless with fear, so great is the anguish that takes place during this psychic collapse.

Agoraphobic symptoms, though not new, are of recent introduction into science (1871). Two forms of agoraphobia are spoken of, namely, *primary* and *secondary.* The primitive form may occur suddenly in apparent good health and normal mental conditions; the secondary form occurs as an accessory phenomenon complicating a previous pathological condition; it is slow and progressive, and may coexist with other neuropathic conditions. *Primitive* agoraphobia may come on suddenly without assignable cause amid varying circumstances: in a boat, during a lecture, or while skating, at the sight of an extended horizon, or while looking at the summit of a high monument, as is the case with two of the writer's patients, who cannot look up to the dome of the Capitol or the summit of the Washington monument without being seized with agoraphobic symptoms. In one case a patient could not look out upon the sea without symptoms. There was also the "tormenting fear of heights," the rooms on a second story being unbearable; and the patient, in crossing a high bridge, always did so in diagonal lines to avoid the sight of the space between him and the water below. *Secondary* agoraphobia comes on slowly, generally in patients whose neurotic antecedents are bad. Numerous prodromes, more or less painful and persistent, are experienced, and at a certain time, while alone in a public place or highway, or under analogous circumstances. Intense emotion and momentary suspension of motor power complete the attack. These often disappear spontaneously, when the sufferer, in crossing a space, can fix his eye on some limited object, as a carriage, a street lamp, a tree, or an open umbrella held over his head; and often the companionship of a small child, or even the support of a stick, will act as a preventive. Among late cases is that of an officer who escaped agoraphobia, brought on at the sight of carriages and pedestrians, by always taking an orderly along and keeping in the least frequented streets. He did not have these symptoms outside of the city in a suburban village, nor did they come on when riding through a crowded street at the head of his regiment.

ETIOLOGY.—But little is known of the cause or of the precise nature of agoraphobia. Most of the predisposing or exciting causes of ill health or of neurasthenia may bring it about. In fact, one may become agoraphobic from moral weakness. The atrophy of will that allows imagination full career and gives rise to the superstitious fears, moral miseries, and morbid impressions that assail certain persons, may cause violent commotion of the organism with psychic sensations of terror. It is satisfactorily established that in agoraphobia there is a kind of moral softening, a nervous adynamia, a psychic insufficiency that may dominate the faculties of the individual and sterilize his acts. Whether the condition arise from organic insufficiencies, such as non-activity of the eye or of the ear, brain trouble resulting from anæmia, fatty heart, hemorrhoids, lesion of the cervix uteri, abscess of the liver, or from a morbid state of the ganglionervous apparatus, we are not prepared to say in the present state of our knowledge of the subject. But opinion warrants the statement that the pathological change in agoraphobia is cerebral, and arises from functional irritation of the cortical sensory centres forming the anatomical substratum of ideation.

DIAGNOSIS.—Outward signs of agoraphobia are in general facial. It should not be confounded with epilepsy, hypochondria, or the different forms of vertigo. Though closely allied to simple melancholia, agoraphobia is said never to occur in hypochondriacs. The morbid and excessive emotivity of agoraphobia is variable, while the influence of hypochondria is constant. Seeming impossibility to give clearer physical notion of the disease is due to the fact of its purely mental nature. It is a curious fact that none of the recorded cases has occurred in ignorant persons. Some are described as altruistic, others as suffering from human egoism with a tendency to complain, to weep, and to keep in the background generally. Nor did any of the cases have illusive transformation, but myopia and dyschromatopsia appear as associated elements. Suicidal impulses are reported to have occurred in several cases. The majority were in adult men of education and intelligence who in nearly every instance kept the symptoms concealed from every one as long as possible for fear of being thought insane. Cases of agoraphobia seldom or never reach asylums.

Conditions likely to be confused with agoraphobia are *basophobia* and *astasia-abasia*. In basophobia the patient by a sort of auto-suggestion persuades himself that it is impossible to stand upon his legs. In astasia-abasia he can neither walk nor stand, but not from fear; he has no timidity nor agony. The basophile has no dread of space; his only fear is inability to stand without agony. In astasia-abasia there is neither fear nor agony; only loss of memory of coordinate movements of station, which affects standing or walking.

PROGNOSIS.—As a rule uncomplicated agoraphobia is not dangerous. No definite period may be assigned for its termination. Forecast depends on the personality of the patient and upon the removal of physical conditions of which the complaint may be a sequence.

TREATMENT.—Drugs in agoraphobia are of less consequence than the removal of the cause, which is to be done mainly by moral treatment. The primitive form often disappears spontaneously, but the secondary form presents all possible and impossible difficulties that the neurologist may expect to meet. Antispasmodics, ergot, the bromides, tonics, and iron, cutaneous revulsives, cups, hydrotherapeutics, electricity, purple spectacles, and suggestion are among the useful indications. A case has been bettered after an operation for hemorrhoids; in another the symptoms disappeared after aspiration of the liver and draining pus from an abscess, and in a case with aural symptoms cure followed dilatation of the Eustachian tube. Two cases caused by tænia have been cured after removing the cause. Another case improved after residence in the country, a course of hydrotherapeutics, and the avoidance of tobacco. In addition to combating functional and physical alterations with proper medication, there must be a radical and complete change in the habits and surroundings, such as may be obtained from a sea voyage, and as much opposition as possible to the conditions in which the disease has originated; above all, the physician should order and enforce a course of moral gymnastics that shall train the patient's imagination, and tame his terror by progressive and regular steps.

Irving C. Rosse.

AGRIMONIA (*Agrimony*).—A genus of about a dozen species (fam. *Rosaceæ*), widely distributed through the Northern hemisphere. The species which has been chiefly used in medicine is *A. Eupatoria* L., common in both Europe and America. Its use is merely of historical interest, as the small amounts of volatile oil, tannin, and bitter substance impart but feeble aromatic and astringent properties, and it is now scarcely used.

H. H. Rusby.

AGUA AZUFROSA DEL TOPO CHICO, or "*San Bernabé.*"—Situated in state of Nuevo Leon, about eight kilometres north of the city of Monterey. Communication by way of the National Mexican Railroad. Chemical composition, Dr. J. Gonzalez y Lambert:

Solids.	Gm. per Litre.
Sulphurous acid	0.0027
Sodium chloride	0.0740
Calcium chloride	0.0100
Magnesium	0.0190
Bicarbonate of lime	0.0270
Bicarbonate of soda	0.0250
Sulphate of lime	0.1040
Silicate of alumina	0.0270
Silicate of lime	0.0850
Total	0.3737
Gases.	**c.c.**
Carbonic acid	2.5
Nitrogen	97.5
Total	100.0

Uses: In rheumatism, in dysmenorrhœa, in hepatic and splenic congestions, in phosphaturia, in certain neuropathies, in diseases of the skin, and especially in the treatment of nocturnal incontinence of urine. The water at the spring has a temperature of 41° C. There is a bathing establishment, which was founded by General Reyes.

N. J. Ponce de Léon.

AGUA CALIENTE.—This term, which in English is equivalent to "hot springs," occurs repeatedly in the list of the mineral springs of Mexico and of those parts of the United States which formerly belonged to Spain. Thus, for example, in the state of Michoacan, which lies to the south and west of that of Mexico, there are three springs which bear this name. The first is situated about 16 km. from the chief settlement in the municipality of Angamacutiro, and is reached by a rather poor driving road. It has a high temperature which is apparently constant, and the volume of water is quite large. Among the laity it has considerable reputation as a remedy for rheumatism and for affections of the chest. No bathing establishment has yet been built.

Another spring of nearly the same name ("El Agua Caliente") is situated in the municipality of Penjamillo. According to Zuñiga, the water of this spring is only lukewarm and is potable.

The third spring, which is known as the Agua Caliente de Yurécuaro, is located in the municipality of Yurécuaro. The temperature of the water is 30° C. It is recommended for the treatment of rheumatism and diseases of the skin. No bathing establishment exists.

In the state of Jalisco there are no less than eight springs which bear the name of Agua Caliente. They are the following: La Agua Caliente, in the municipality of Amacueca; Agua Caliente, in the municipality of Chiquilistlán; Agua Caliente de la Cofradía, in the municipality of Cuquio; La Agua Caliente, situated about 8 km. from the city of Ejutla; Agua Caliente, in the municipality of Teuchitlán; Agua Caliente de la Cuña, in the municipality of Yahualica; Agua Caliente Chica, in the municipality of Zapopan; and Agua Caliente, in the municipality of Zapotlanejo. Not a single bathing establishment exists at any of these springs, and in the case of only one of them does the report give even an attempt at an analysis of the water. The introductory portion of this report is quoted here in full. It explains some of the difficulties which were encountered by the Institute in its efforts to collect reasonably full data in regard to the mineral springs of the republic of Mexico:

"The National Medical Institute of Mexico has begun to publish the data that it has been able to collect regarding the mineral waters of our country, not only because it wishes to have their existence known, but because it hopes to have these data completed and corrected, if possible, by people living in the neighborhood of the springs, or by the physicians of the localities.

"The data collected by the Institute, as well as the waters of which the analyses are given in this report, have been forwarded to it almost exclusively by the

Governments of the different municipalities. Unfortunately, answers to the questions submitted to them have not been obtained in many instances, and in others some of the answers are incomplete. For this reason, and from the fact that there was not available a sufficient quantity of water from each spring for the purposes of a satisfactory analysis, it is possible that some of the statements made in this report are incorrect. They certainly are not complete; but we believe that the best method of completing them is to publish those that we have, in order that we may at some later date be furnished with those that are wanting. It is desirable that physicians should furnish us with their actual experience with these waters, because, although one may infer from the composition what their probable effects are, only practical experience can teach us the therapeutic uses of the same." * *N. J. Ponce de León.*

AGUA DE VIDA SPRINGS.—Alameda County, California.

Access.—Via Central Pacific Railroad, a three-hour ride from San Francisco, to Livermore, thence a few miles by carriage southeast to Springs, hotel, and cottages.

These springs are located in Arroyo Mucho, among the foothills of Cedar Mountain, at an elevation of 1,700 feet above the sea level. There are a number of mineral springs at this place, both carbonated and sulphureted. The lower drinking spring is of the former type. Its water is clear, sparkling, and exceedingly palatable. An analysis by Dr. Winslow Anderson resulted as follows:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	4.02
Sodium carbonate	3.65
Sodium sulphate	14.73
Potassium carbonate	0.55
Magnesium carbonate	7.95
Magnesium sulphate	0.46
Calcium carbonate	13.75
Calcium sulphate	0.10
Alumina	0.37
Silica	0.42
Organic matter	Trace.
Total solids	46.00
Carbonic acid gas	19.25 cubic inches.

The physiological action of this water is aperient, antacid, diuretic, and tonic. It is recommended in cases of acid dyspepsia and as a diuretic in cystitis and congestion of the kidneys.

The upper or larger spring is mildly sulphureted alkaline and saline, as shown by the following table of its contents:

One United States Gallon Contains:

Solids.	Grains.
Sodium chloride	5.07
Sodium carbonate	2.25
Sodium sulphate	17.50
Potassium carbonate	Trace.
Magnesium carbonate	3.19
Magnesium sulphate	8.70
Calcium carbonate	11.92
Calcium sulphate	4.35
Manganesium carbonate	Traces.
Alumina	0.40
Silica	0.55
Organic matter	Traces.
Total solids	53.93

Gases: Sulphureted hydrogen, 2.74 cubic inches; carbonic acid, 9.25 cubic inches.

Temperature of water, 57.5° F. This water has a laxative influence, and as such is serviceable in abdominal plethora and chronic constipation.

Important improvements have recently been made on the grounds at Agua de Vida Springs. The naturally picturesque location has been further beautified by the construction of broad driveways, rustic bridges, cool arbors, and other pleasing adjuncts. The visitor will find an excellent hotel, surrounded by comfortable and spacious family cottages.

James K. Crook.

AGUA FRIA.—Municipality of Tajumarea, Michoacan, Mexico. "Agua Fria" embraces three mineral springs, viz., "La Rosa," "La Pela," and "La Laguna," distant about 20 km. from Ucareo. The waters are thermal, those of La Rosa having the highest temperature. According to Zuñiga they contain salts of sodium with hydrogen sulphide. There are no facilities for comfortable bathing, but the residents of the locality resort to the springs for the treatment of rheumatism, paralysis, and diseases of the skin.

N. J. Ponce de León.

AGUA HEDIONDA.—Situation, three kilometres to the northeast of the city of Cuautla, in Morelos, state of Morelos. Transportation, by way of the Interoceanic Railroad to the city of Cuautla, and by carriages thence to the springs. These waters derive their name from their strong odor of sulphureted hydrogen. They are located about three miles northeast of the city of Cuautla. The springs issue from the earth on the borders of a small ravine and discharge their united stream into the River Cuautla. At the source of the largest spring a pool of considerable size is formed, which is used for bathing. The overflow of this pool into the ravine forms a small cataract, which is utilized by the bathers as a natural douche or affusion. Another spring, also of considerable size, is located 120 metres to the west of the first spring. It also furnishes a very desirable natural bathing pool. Two more springs of smaller size are located in the vicinity. The waters of these springs have been subjected to a careful examination by Morales and Eduardo Liceaga. The water of spring No. 1 is described as being colorless and limpid, and forms no sediment. It has a bitter taste, and at the springs a sulphurous odor. On evaporation it shows a dried residue of about 124 grains per United States gallon, composed chiefly as follows: Sulphate of calcium, 70 grains; sulphate of magnesium, 30 grains; and choride of sodium, 17 grains. There are also small quantities of iron, silica, and organic matter, with carbonic acid and sulphureted hydrogen gases. The water is not adapted for general drinking purposes. Spring No. 2 is somewhat less strongly mineralized than No. 1, but contains essentially the same chemical ingredients, and possesses similar physical characteristics. Like No. 1 its water is not potable. The average daily temperature of these waters is 78° F. In small doses the waters are said to possess tonic and stimulant effects, and to promote the appetite and the activity of the digestive functions. An attempt was made many years ago, in 1854, to develop the springs as a health resort, but the enterprise was allowed to languish and the locality was almost forgotten. During the last few years, however, the springs are again coming into notice, and we are informed that in the course of the Mexican spring resort season, from October to February, an increasing number of persons come annually to avail themselves of the benefits of the baths. Persons suffering from scaly skin affections, from certain forms of paralysis, from rheumatism, and from hepatic, renal, and gastric disorders, are said to derive much benefit from a course at these springs. The valuable character of the waters found here, the picturesque location and attractive scenery, and the nearness of the waters to the city of Cuautla, all mark this as a mineral spring resort of some promise.

N. J. Ponce de León.

* The facts which we are able to publish in the present edition in regard to Mexican mineral springs have been furnished to us through the courtesy, first, of Porfirio Diaz, President of the republic, and next, of Dr. Fernando Altamirano, director of the National Medical Institute in the city of Mexico. The documents which contain this information are partly in printed and partly in manuscript form; and as they are all written in Spanish, Dr. Ponce de León, of this city, has very kindly undertaken to furnish concise abstracts from them in English.—Editor.

AGUA TIBIA.—Municipality of Taretan, Michoacan, Mexico. This spring discharges a cold sulphureted calcic water. As a bathing medium it has acquired considerable reputation in the treatment of syphilis, although no bathing establishment has been erected.

N. J. Ponce de León.

AGUAS CALIENTES.—California. In the southern part of this State are situated a number of thermal springs, known as *Aguas Calientes* (hot waters). Some of them have acquired considerable celebrity. This is especially true of the springs of Coahuila or Cabojos valley, on Warner's Ranch, some fifty miles from San Diego City, in San Diego County. These waters vary in temperature from 58° to 142° F., and are believed by the native population to be an infallible remedy in syphilis and cutaneous affections. Subacute and chronic rheumatism, renal and hepatic disorders, and strumous diseases are also successfully treated here. Accommodations have been provided for visitors. The following analysis was made by Prof. Oscar Loew:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	8.30
Sodium sulphate	Trace.
Sodium chloride	31.00
Calcium	Trace.
Magnesium	Trace.
Lithium	Trace.
Silica	Trace.
Hydrosulphuric acid	Trace.
Organic matter	Trace.
Total	39.30

The examination was evidently not complete. The water undoubtedly contains sulphureted hydrogen gas in considerable quantities.

Another Agua Caliente of some repute is located in Keon County, thirty miles from Caliente station, on the Southern Pacific Railroad. The waters are sulphureted and their temperature varies from 80° to 100° F., but no analysis has been made. There is a small resort at the springs.

James K. Crook.

AIKEN.—South Carolina. This little village is situated in the western portion of the State, seventeen miles from the Georgian line, between the Savannah and Edisto rivers, but at a considerable distance from either; it stands upon the elevated tableland or plateau forming the common water-shed of both. From the Atlantic Ocean, Aiken is distant a little more than a hundred miles in a "bee line." The elevation of the town above sea level is 560 feet. The soil is very sandy, consisting, indeed, of little else than such absolutely pure and unmixed sand as is usually found only upon the immediate borders of the sea. Grass grows but scantily, and the vegetation of the surrounding country is such as characterizes a region possessing a dry, porous soil, and, in consequence, a dry atmosphere. The yellow pine of the South finds here its congenial habitat. Several varieties of oak are also to be found in the woods about Aiken, and many varieties of flowering vines and shrubs; but the pine is the characteristic growth of the country.

The chief factors in producing the healthfulness of this now celebrated resort are the mildness and general equability of its winter climate; the preponderance of bright sunny days, which enable the invalid to pass much of his time in the open air; and last, but by no means the least important, the remarkable dryness of the air, already alluded to, depending upon the peculiar character of the soil and the distance from any large body of water. With the exception of certain stations lying in close proximity to, or west of, the Rocky Mountains, there is no place in the United States which possesses a drier air than that which exists at Aiken.

To demonstrate the small amount of variability in the temperature possessed by the climate of Aiken, the following figures are appended; they are deduced from observations taken by Dr. C. F. McGahan, and embrace a period of seven years.

Month.	Nov.	Dec.	Jan.	Feb.	March.	April.
Daily variation	13.14	14.57	10.39	12.43	10.25	18.52

Aiken being only a winter resort, Dr. McGahan's observations have been confined to that season which extends from October to May, and therefore the following figures, quoted from "Smithsonian Contributions to Knowledge," No. 277, are here inserted. They show the mean temperature at Aiken for each of the twelve months, for each of the four seasons, and for the year. The observations upon which these figures are based were taken at 7 A.M., 2 P.M., and 9 P.M. (by Messrs. H. W. Ravenel, J. H. Cornish, and Newton), and extended over a period of seventeen years, from January, 1853, to December, 1869.

January	44.15°	July	78.80°	Spring	61.32°
February	47.83°	August	77.19°	Summer	77.36°
March	53.22°	September	72.23°	Autumn	61.96°
April	61.49°	October	61.80°	Winter	45.82°
May	69.25°	November	51.84°	Year	61.61°
June	76.08°	December	45.48°		

The mean relative humidity from October to May 1st, taken from the following tables, is 58.75 per cent. The prevailing winds are from the southwest, and the number of clear days is unusually large.

METEOROLOGICAL RECORD TAKEN AT AIKEN, S. C., BY DR. CHARLES F. MCGAHAN, VOLUNTARY OBSERVER, UNITED STATES SIGNAL SERVICE.—LATITUDE, 33° 32′; LONGITUDE, 81° 34′; ALTITUDE, 565 FEET; PERIOD OF OBSERVATION, 1888–1894.

	Mean Temperature for Months at Hour of			Mean temperature of months. (7+2+9+9÷4).	Mean temperature from maximum and minimum.	Mean barometer.	Direction of prevailing wind.	Mean relative humidity.	Average number of clear days.	Average number of rainy and cloudy days.	Mean rainfall in inches.
	7 A.M.	2 P.M.	9 P.M.								
November	48.33	61.47	52.69	53.54	55.30	29.623	S. W.	59.65	27	3	1.33
December	42.48	57.05	48.02	48.80	50.71	29.540	W. & S. W.	58.58	26	5	2.65
January	41.28	52.67	44.54	45.75	47.87	29.615	N. E.	63.17	23	8	4.68
February	44.41	56.84	49.92	50.27	52.01	29.622	S. W.	60.31	24	4	4.35
March	49.55	59.80	53.36	54.02	52.03	29.494	S. W.	57.90	26	5	6.07
April	57.23	71.78	53.26	58.88	64.33	29.547	S. W.	52.78	29	2	2.33
Mean	......	......	......	51.89	53.70	29.573		58.73			

These observations were taken with United States Signal Service instruments, and according to their regulations; the thermometers being exposed on the north side of the house in the shade, and protected from reflected sun rays.

We possess, then, in this climate all of the attributes of a health resort favorable for the relief of pulmonary tuberculosis, except altitude and its accompaniments—viz., pure dry air at a moderate temperature, a dry and well-drained soil, an absence of high winds with an occasional exception, and an abundance of sunshine. Experience through a long series of years in the treatment of pulmonary tuberculosis at this place verifies this conclusion. In the writer's opinion, the high-altitude climates are superior, as proved so far by results, to those without altitude; but it must nevertheless be borne in mind that not all cases of pulmonary tuberculosis are suitable for the high altitudes, and in such a climate as Aiken we have a most valuable resource for such cases as, from limited vitality or other unfavorable conditions, are unsuitable, at least for a while, for the high altitudes. Here we can surely carry out to perfection the modern open-air treatment, which after all is the essential part of the climatic treatment of pulmonary tuberculosis.

Moreover, the climate of Aiken is suitable for patients who are suffering from other diseases, such as rheumatism and albuminuria; for convalescents from acute diseases or injuries; and for large numbers of individuals who, for one reason or another, possess little physical vigor. Here they can exist in comfort with a minimum expenditure of vital force.

"Malaria," says the late Dr. Geddings, "is remarkable for its absence. During a practice of fifteen years, I have never known a case to originate here."

The water supply is derived from an artesian well which is 780 feet deep, the last 200 feet being through a solid bed of granite. Its purity is attested by an analysis which was made in 1898 by Prof. Charles F. Chandler, of Columbia University, New York.

The system of sewerage is the one that has been tested thoroughly for the past twelve years by the State Board of Health of Massachusetts for its inland towns, and is considered by sanitary engineers the best for such places.

Amusements.—On account of the sandy roads, this is the ideal country for horseback riding; then there are fox hunts for those who are more venturesome. A mile race track is one of the features of the place, and some of the best race horses in the East winter here. The Palmetto Golf Club has the finest links in the South. For those who enjoy the wheel, there is an eight-mile track, perfectly level, running through the woods and fields.

The Highland Park Hotel, which was destroyed by fire in 1898, has not been rebuilt, owing to the opposition of the cottagers, but before another year has elapsed it is confidently expected that Aiken will have as fine a hotel as any resort in the South.

The special feature of the place is the cottage life, and cottages of all sizes can be rented, from the simple three-room cabin to the pretentious villa provided with all the modern improvements. There is a modest family hotel in the town, and there are also numerous boarding-houses.

Any account of Aiken would be incomplete without mention of the Aiken Cottage Sanitarium, founded, in 1896, for the treatment of cases of incipient phthisis. It is a charity, and is modelled after the institution of Dr. Trudeau's, at Saranac Lake. The cottages at present can accommodate only eleven patients, but provision will soon be made for the care of twenty cases. The treatment consists mainly in providing good nourishment and keeping the patients in the open air from seven to nine hours a day. The institution is under the charge of Dr. C. F. McGahan.

The educational advantages of Aiken are very good, there being several excellent junior schools, and a high school which fits its pupils for college. Churches of all denominations are to be found here.

In conclusion it may be added that Aiken is situated upon the Southern Railroad, with three daily trains from New York. For much of the above account the writer is indebted to Dr. McGahan.

Edward O. Otis.

AILANTHUS Desf.—A genus of some seven species, in the family *Simarubaceæ*, native to Eastern Asia and the East Indies, the *A. glandulosa* Desf. common in the Eastern United States. It is in this species that medical interest chiefly centres.

It has been observed that the tree is odious to flies, which, it is said, will not approach even decayed meat when placed among its leaves. Mild poisoning has been recorded from the habitual drinking of water into which the roots of the tree had penetrated, and into which its leaves had fallen. The symptoms were those of simple gastric irritation, similar to what would be caused by the amaroids contained in quassia and similar drugs. The bark and leaves have been used medicinally, and are purgative and anthelmintic.

The constituents of the plant are known only in the most general way. An amaroid, a volatile oil, and a resin are active. The pure resin has been found purgative, but not anthelmintic, while the oleoresin is an efficient tænicide. The tænicidal property is therefore assumed to reside in the dark-green volatile oil. This oil, taken by inhalation, is a powerful depressant poison, producing vomiting, dizziness, and cold perspiration. Taken by the stomach, these effects have not been observed, though due precautions in regard to dosage should be observed.

The dose of the powdered leaves, as a tænicide, is 0.5–2.0 gm. (gr. viij. to xxx.), of the oleoresin 0.2 to 0.6 gm. (gr. iij. to x.).

In India, the juice of the leaves and bark of *A. excelsa* Roxb. have been used from ancient times as a tonic, especially in convalescence after parturition. The bark of this and of *A. malabarica* D. C., is also used as a vegetable bitter, in forms of dyspepsia.

H. H. Rusby.

AINHUM.—(Synonyms: Ainhun; dactylolysis spontanea; *Abnägen* [German]; *Dactiliolisia* [Spanish].) The etymology of the word is usually attributed to Africa, and is derived from a word meaning to "saw off." Matas states that the word ainhum is from the negro patois of Brazil, *ainhoum*, meaning a "fissure."

Definition.—Ainhum is a disease of tropical countries, and is characterized by the gradual painless amputation of one or more joints of one or more toes by a trophic process of mixed atrophy and hypertrophy.

History.—While the first accurate description of the disease was made by da Silva Lima, of Bahia, Brazil, in 1867, as much earlier as 1860 Dr. Clark called attention to ainhum in the Gold Coast natives. Since 1867, a number of observers have reported upon the disease, notably Duhring and Wile, and Matas in this country. Zambaco Pacha, in the Transactions of the 1897 Lepra Conference in Berlin, writes at length upon the condition in its relation to leprosy.

Etiology.—The cause of the disease is not known. It has been found in the negro races in the cases reported; it occurs in adults, and is essentially a tropical disease, exotic cases occurring occasionally elsewhere. The parasitic nature of the disease is maintained by some, but it has not been proven. Zambaco Pacha maintains the identity of ainhum and trophic leprosy of the mutilating type.

Symptoms.—Prodromes are absent. There may be some itching, but usually the disease is evidenced by a slightly constricting band, a furrow, at the digito-plantar fold of the fifth toe. At times other toes may be affected. For example, I have seen the great toe involved, at the New Orleans Charity Hospital. The furrow gradually becomes more pronounced, harder in consistency, and more and more constricting, the confined portion of the digit increasing in size so as to lose the shape and form of a toe. There is absence of inflammation and of subjective symptoms, excepting occasional pain. As the constricting band narrows the toe becomes more and more tumefied, until finally only a small pedicle remains. From this the tumor either sloughs off, is torn or knocked off, or is intentionally removed. When ulceration takes place,

FIG. 61.—Annular Scleroderma of the Little Toe Preceding Spontaneous Amputation. (Case of Ainhum; service of Dr. R. Matas, Charity Hospital, New Orleans, La.)

FIG. 62.—Diseased Foot Before Operation. (Case of Dr. C. Peña, Córdova, Republic of Mexico.)

there is a distinct odor, of a nauseous character, resembling that of the neurotic ulcer. The pedicle, or base, heals kindly. The process lasts months—even years in some instances.

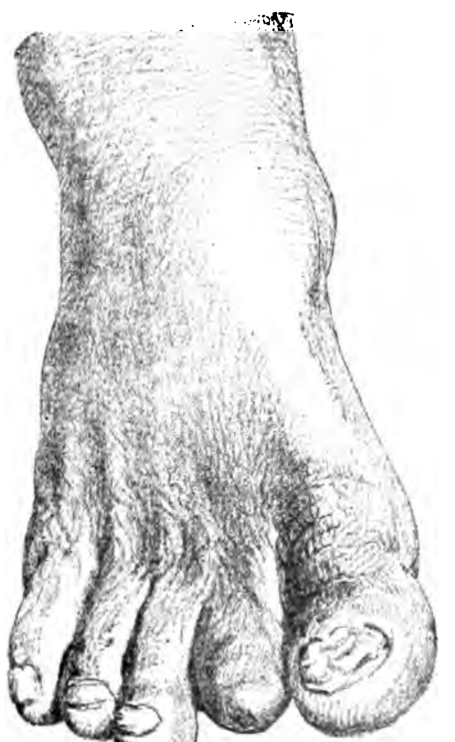

FIG. 63.—The Same After Operation. (Case of Dr. C. Peña.)

PATHOLOGY.—Unna believes the condition to be "a ring-formed scleroderma with callous formation of the epidermis, leading to secondary total stagnating necrosis, resembling artificial snaring of tumors. There is a primary inflammation with marked hypertrophy of the epidermis, the papillæ being narrowed and elongated. In the papillary body there is cellular infiltration; the vessels are dilated. The tumefaction of the toe indicates a stagnation of lymph and fat, which gradually causes degeneration of all of the constituents of the cutis, a rarefaction of the bones, and the disappearance of the phalanges." In this most observers agree, the latest contribution (see Figs. 64, 65, and 66) indicating the above process.

DIFFERENTIAL DIAGNOSIS must be made especially from Raynaud's disease, from paronychia, from the neurotic ulcer, and from leprosy.

Raynaud's disease is nearly always painful, occurs seldom on the lower extremities, is quite common on the upper extremities, and the trophic change is evidenced most often by the occurrence of preliminary lesions, *e.g.*, vesicles or bullæ.

Paronychia is inflammatory throughout and occurs on the ungual phalanx always.

The *neurotic ulcer* begins as a callosity, is circumscribed and deep seated, occurs usually on the plantar surface of

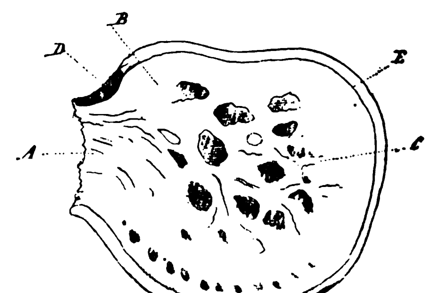

FIG. 64.—Longitudinal Section of the Amputated Toe. *A*, Section of the pedicle; *B*, fibrous fasciculi or bundles; *C*, collections of fatty tissue; *D*, remains of the nail; *E*, epidermis. (Case of Dr. C. Peña.)

the heel or great toe, and is never located just at the digito-plantar fold of the fifth toe. It is characterized almost from the start by the loss of the central tissue and by a persistent slough, exulcerating and discharging freely.

Leprosy of the mutilating type has points of resemblance to ainhum, especially when the latter disease is well

advanced. Leprosy, however, has no preference for the negro, and it is not a tropical disease. The trophic lesions of leprosy are found on any toe or any finger. These are almost invariably associated with other present or past manifestations. The initial evidence of mutilating leprosy is a macule, excoriation, or bulla on the site of the destruction. The initial evidence of ainhum is a callous furrow, without inflammatory redness.

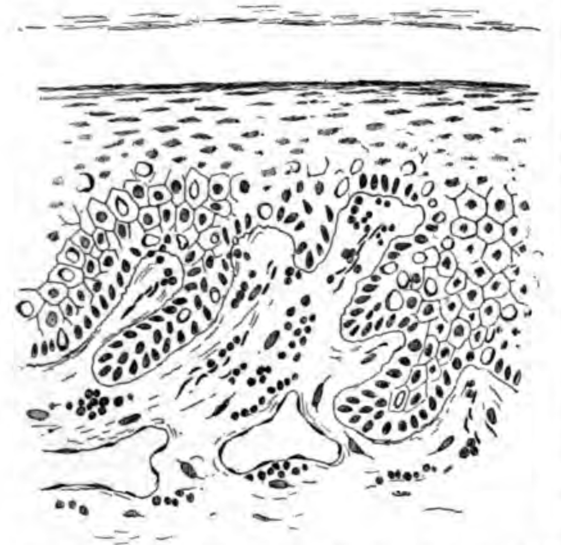

FIG. 65.—Section of the Skin. Moderately enlarged. (Case of Dr. C. Peña.)

Zambaco Pacha (*loc. cit.*) elaborately argues this point of resemblance, arraying a large number of observers in confirmation of his opinion, but the burden of proof rests with him.

TREATMENT.—All observers agree that perpendicular and free incision of the circular bands may arrest the process, but that usually the course of spontaneous amputation is completed, unless artificially or surgically produced. *Isadore Dyer.*

FIG. 66.—Section of a Blood-Vessel and of a Nerve. Moderately enlarged. (Case of Dr. C. Peña.)

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AIR.—To appreciate the various sanitary relations of the atmosphere, the subject must be studied from the physical as well as from the chemical standpoint. In considering the physical aspects of air, attention must be given to the subjects of atmospheric pressure, light, heat, humidity, and electrical condition.

The air is an invisible gaseous ocean. In it, as in all gases, there is no cohesion between the molecules. They are apart from one another, and their tendency to spring farther apart and occupy more space is so great that a restraining force is needful to prevent expansion and attenuation. Air at the sea level, the bottom of the aerial ocean, is compressed by the weight of the superincumbent air. This weight expresses the influence of gravity on the air as a whole, or the influence which the earth exerts on the molecules of its atmosphere to keep them from escaping into limitless space or from being whirled away by the centrifugal force of the diurnal rotation. The pressure of the atmosphere at the sea level balances a column of water 34 feet high. It forces water up the cylinder of a pump in proportion as the air pressure within the cylinder is lessened by the working of the piston, but the raising power of the pump is limited by the height mentioned. Similarly at the sea level the atmospheric pressure balances a column of mercury 29.92 inches, or 760 mm., in height (at 45° N. latitude), and as this number of cubic inches of the liquid metal weighs 14.75 pounds, or 1 kgm., to the square centimetre, the air pressure on every measure of surface becomes known. Generally, however, air pressure is expressed in inches of mercury as being more convenient than a statement of the actual weight on a given area. The pressure on a surface of one square foot amounts to nearly a ton. The average man has a surface of about 15 square feet, but the 15 tons of air pressure under which he moves are unfelt because of the fluidity of the atmosphere. The freedom of movement possessed by its molecules transmits their pressure in all directions. Air permeates all porous bodies, and the internal pressure in bodies so permeated counteracts the external pressure. Noticeable effects of air pressure are seen or felt only when there are local disturbances, as when the tissues are pressed by the weight of the atmosphere into the rarefied air of a cupping glass.

The higher we ascend into the atmosphere the less is the pressure, because there is less overlying air to affect us by its weight. Heights are measured by the decreased pressure, and balloonists calculate their distance from the earth by the fall of the mercurial column in their barometers. At the sea level, under a pressure equivalent to that of 29.92 inches of mercury, a cubic foot of air weighs 536 grains. Air is increased in bulk as pressure is diminished. At the height of one mile, the barometric column falls to 24.5 inches, equivalent to a pressure of 12.04 pounds to the square inch. Under this lessened pressure, a cubic foot of sea-level air would expand, other things being equal, to $29.92 \div 24.5$, or 1.22 cubic feet, and one cubic foot of this rarefied air would weigh only 439 grains. The pressure at two miles being equivalent to only 20 inches of mercury, one cubic foot of sea-level air would expand to $29.92 \div 20$, or 1.49 cubic feet, and the weight of a cubic foot of this expanded air would be 360 grains. With increased height there is diminished density, but as the elastic force which separates the molecules becomes lessened by their separation, there may be a certain condition of tenuity in which this force is unable to overcome those which operate in restraint. The depth of the atmospheric

ocean has been estimated variously at from 45 to 350 miles or more.

Light from the sun or other sources passes through the air without illuminating it. Were it otherwise we should be able to see the air. We see things by the light which they emit or reflect, but the air merely transmits. We speak of atmospheric glows and beams of light, of the blue of the firmament and the radiance of morn, but these phrases relate to the visibility of substances in the air. Light is transmitted in straight lines, with the exception of some refraction in the denser strata near the earth's surface; but as more or less of the light is refused a lodgment by every substance on which it falls, and is reflected from one object to another at all angles and hence in every direction, the whole of the air is filled with rays which illuminate objects that are not exposed directly to the source of the illumination. Molecules of watery vapor and minute particles of dust suspended in the air give rise to the apparent diffusion of light in the atmosphere. These account for the dawning light of morn, and the twilight after sundown.

Associated with solar light are actinic and heat rays. The latter are of the highest interest, as being the cause of the tides, currents, and local movements in the atmosphere. Heat rays pass through the atmosphere without warming it. The air of high mountain regions is cold, although the same rays pass through it which may give a tropical warmth to the plains below. It is usually said that the temperature falls 1° F. for every 300 feet of altitude, or about 134 metres for 1° C. This, although not accurate, is useful. If the temperature, average or actual, of a given locality be stated, an approximation to the corresponding temperature of a neighboring plateau may be calculated. Glaisher, during his balloon ascents, found the temperature on a cloudy day lowered 4° F. for every inch of a barometric fall of 11 inches; and the further ascent was marked by a more rapid refrigeration. As 11 inches of mercury indicate an elevation of 12,000 feet, the average ascent for the Fahrenheit degree was about 270 feet. On a clear day the thermometer fell 5° for each of the first 4 inches of barometric fall, 4° for each of the next 9 inches, and 13.5° for the last 3 inches of his ascent. The cold is proportioned to the lessened pressure, 4° F. for each inch; but as the height to be ascended for each inch of fall increases with the ascent, the height for each degree of temperature increases correspondingly.

Air, in expanding under lessened pressure, has its expansion restricted in some measure by the loss of heat attending the expansion, for the volume of a gas is contracted by cold. Air expands $\frac{1}{460}$ of its volume at 0° F. for each degree of increased temperature ($\frac{1}{273}$ in the case of Centigrade). Hence 460 cubic inches or feet or, in general terms, volumes, at 0° F. expand at 60° to 250 volumes, and conversely by a reduction of temperature from 60° F. to 0° 520 volumes contract to 460. On these data is based that which in dealing with air and gases is called the "correction for temperature." The molecules of a cubic foot of dry air weigh, at the sea level, 536 grains. Under the diminished pressure, at 16,000 feet, these molecules would occupy a space of two cubic feet, each foot containing 268 grains; but the coincident reduction of temperature would so modify this that the cubic foot of air would weigh 303 grains. The rarefaction of the atmosphere in mountain regions is thus seen to be somewhat less than we should be led to expect by a consideration merely of the barometric pressure.

Heat, like light, is absorbed in varying proportions by everything on the surface of the earth, and that which is not absorbed is reflected at various angles, so that the air in its lower strata is filled with reflected rays which become manifest only when they are absorbed and increase the temperature of the absorbing substance. Absorbed heat is radiated to cooler bodies in the neighborhood, for the tendency in nature is to an equable distribution. Hence, besides reflected rays, the air may be filled with rays of radiant heat, but in all this there is merely transmission, with no appreciable influence on the air itself. When, however, absorbed heat is distributed by convection the air assumes an active part in the process. A warm substance communicates part of its heat to the air molecules in immediate contact with it. The air thus heated expands and is floated upward by the inflow of colder and heavier air beneath it; and it is thus raised until by admixture with the general mass of the air its rarefaction is lost, or until under unusual conditions of placidity it reaches a stratum of equal rarefaction. The cold air that replaced it in contact with the heated substance becomes similarly warmed and borne upward; and this continued in an uninterrupted sequence gives rise to an upward current of warm air with inflowing currents of colder, heavier air on all sides. We sometimes seem to see this upward current by the side of a heated stove, when its varying density disturbs the passage of the rays of light from objects seen through it, and gives a quivering movement to their outlines. In the sandy districts of southern Arizona and New Mexico, trees and other objects at a little distance from the observer are often tremulously distorted to his sight by the upward currents from the sun-heated surface.

Objects that absorb much radiate much, and those warmed rapidly by absorption cool quickly by radiation. Color has an influence on these movements, for black surfaces absorb and radiate better than white. Radiation and reflection are therefore different processes, for white is the better reflector. The radiant powers of different substances vary much, but it is unnecessary here to do more than indicate in general terms the differences presented by land and water in this regard.

As compared with water, land heats quickly and cools quickly. The heat does not penetrate but accumulates in and immediately beneath the surface. Children know how cool is the underlying sand turned up on the seashore in their holiday play. The surface is hot by day and cool by night, but at a depth of three feet there is no diurnal increase of temperature, and even the heat of a prolonged summer penetrates only about seventy feet, for well water at this depth has the same temperature summer and winter.

Masses of water, on the other hand, heat slowly and cool slowly; the rays penetrate to the depths. The temperature of the surface waters of the ocean is never over 80° F. (26.6° C.) in the tropics, and its diurnal range is small. In higher latitudes the temperature is lower, but the mass of the waters of the ocean, in both high and low latitudes, is never below 39° F. (3.9° C.). Thus the air is warmed intermittently by the land and continuously by the ocean, and its molecules are kept in motion by the convection which is in progress.

The solar rays are the only source from which the air derives its warmth, for, although animal life and the combustion of fuel develop heat, the heat thus developed is merely the liberation of energy derived originally from the sun. Again, although the earth has an internal heat, this heat is not transmitted through the crust, for the superficial strata to a depth of seventy feet are affected by the seasonal warmth of the sun, and not by the interior heat.

The effects of heat on the atmosphere are multiplied and varied by the phenomena attending its action on water. Vapor, invisible as the atmosphere itself, rises from water at all temperatures. The higher the temperature the more rapid the evaporation. Thus vapor is absorbed into the atmosphere, and the amount that can be absorbed increases with increase of temperature. A cubic foot of air at 32° F. is saturated with moisture when it contains 10 cubic inches or about two grains of vapor of water; but at 100° F. (37.8° C.) the cubic foot of air can absorb about 100 cubic inches, or nearly 20 grains. The molecules of the vapor find place for themselves in the intermolecular spaces of the air, but not without crowding aside the air molecules to such an extent that saturated air is lighter than dry air. Air is known to be saturated when the slightest lowering of its temperature causes a deposition of moisture. We call such a deposition cloud when in the air above us, fog

or mist when in the air around us, and dew when deposited at night on vegetation and other highly radiating surfaces. The *dew point* may be found by noting the temperature at which moisture appears on the outside of a test tube, cooled by the evaporation of ether in its interior. Usually an approximation to it is obtained by the wet bulb thermometer, from which the actual dew point may be calculated or gathered from Glasher's tables. Moisture in the air is expressed as *relative humidity* on a scale of which 100 is the point of saturation. Absolute figures give no satisfaction. With two grains of moisture in a cubic foot of air the air, as we have seen, may be very moist or very dry. If the temperature is 32° F., the air is saturated; if it is 100° F., the air is so dry that it is ready to take up 18 grains more before it becomes saturated.

Evaporation aids radiation and convection in cooling a warm, moist surface. The soldier in a summer camp moistens the outside of his canteen and hangs it on a branch that the passing breeze may cool its contained water. Even the surface of the water of the tropical oceans is cooled slightly at night. It is, however, not so much by the production of a local coolness as by the transference of heat from one place to another that the chief influence of evaporation is exercised. From the surface of the ocean, particularly in the warmer latitudes, evaporation is going on at all times. An upward movement of moist, warm air is continuously in progress. Partial condensation occurs by the time this air reaches a stratum of its own density, but the clouds there formed are usually hurried by air currents to other and colder regions of the globe before the particles of condensed vapor become aggregated and fall as *rain*. The heat gathered from the tropics is thus distributed to other parts of the earth, the air of which is warmed by condensation above as well as by convection from below. Moreover, the clouds absorb heat radiated from the surface of the earth, thus preventing its dissipation into the ether beyond. Every object on the surface is thus kept warmer than it otherwise would be. Clouds act as a blanket to keep the air and the earth under them warm. Any roof, however flimsy, even the spreading branches of a tree in foliage, is a protection against the cold of radiation into space. The great heat of the direct rays of the sun at high altitudes, where the surrounding air is intensely cold, is attributed to the freedom of the air from intercepting moisture.

Electricity pervades the atmosphere. It is generated by the evaporation of water, the friction of the wind on the surface, and of the molecular constituents of the air each on the other; but its relations to these constituents are not clearly understood. It is greatest in cold, dry weather, but the greatest electrical disturbances are associated with condensation and rainfall.

Our knowledge of the effects of heat and moisture enables us with but little effort to recognize the causes of many meteorologic phenomena that have important bearings on the well-being and comfort of the human race. Meteorology is probably the oldest of the sciences, for man, even in the earliest days of his racial existence, found it necessary to study the probabilities; and the weather wisdom of every nation is embodied in proverbial expressions. The co-operative work of modern times, made possible by the use of the telegraph, has enlarged our knowledge and broadened our views of these phenomena, so that we now have a useful understanding of the general as well as the local movements of the atmosphere.

Extending for a few degrees on each side of the equator is a region of calm and light variable winds, known to sailors as the doldrums. Here the uprising of the moist, warm air leads to condensation in the higher strata. Heavy rains fall, and the heat liberated during the condensation rarefies the relatively dry air of the upper regions and develops a swell on the surface of the atmospheric ocean which divides or flows over, one-half to the north, the other to the south, while an inflow in the lower strata restores the aërial equilibrium. The inflowing currents do not come from the poles; they reach only from the 30th parallels, and their motion is more or less obliquely from the east on account of the diurnal revolution of the earth. A belt of variable winds is found about the 30th parallels. Here the upper current from the tropics impinges (in the northern hemisphere) on a northeast upper current from the Arctic circle, and the swell of their meeting occasions an increased pressure at this point. Escape for the accumulated air is found below, southward constituting the trade winds and northward constituting the regular southwest winds of the north temperate zone. At the Arctic circle is another doldrum belt into which flows the wind last mentioned and a surface current from the northeast. These, warm and cold intermingling, produce condensation and rainfall and an expansion or swell which overflows into a northeast upper current over the temperate zone, and a southwest upper current toward the pole. The surface currents affect the air to a height of 16,000 feet, involving about one-half of the weight of the atmosphere, and their velocity averages about 15 miles an hour. This constitutes the general circulation of the atmospheric ocean, but there are many secondary currents, as that between land and sea. In fact innumerable causes of greater heating at one place than at another give rise to local currents.

The resultant of all the meteorological conditions constitute climate; but temperature, as being the most notable condition, is usually adopted to give formal expression to the character of a climate. Temperature depends on latitude, altitude, and the presence of large bodies of water to reduce the daily and seasonal ranges. One of the first discoveries by those who collated the meteorological observations of the medical officers of the United States Army was the climatic importance of the great lakes. In New England the influence of the ocean was found to modify the mean temperature. In the interior of New York, the daily range increased and the seasons were strongly contrasted. Farther west, near the great lakes, a climate similar to that of the seaboard was again found, but in the interior beyond them, extreme changes again became the rule. Water tempers the winds which blow over it and loads them with vapor for subsequent condensation and warmth. The regular southwest winds of the temperate zone reaching Europe from the Atlantic and California from the Pacific Ocean give these shores a climate markedly different from that of the Eastern coast or interior of the United States. The air of continental interiors is dry and the solar rays beat with full intensity on the surface, while at night there is no protection against radiation into the cloudless skies.

That climate has a powerful influence on the welfare of man is manifest when we compare the weakness and indolence of tropical races with the strength and energy, mental as well as physical, of those of the temperate zones. Since the earliest ages it has been a favorite theory that diseases come upon mankind through the air. The box of Pandora was opened, and its contents scattered to the winds. A peculiar "epidemic constitution of the air" was formerly accepted as accounting for the unusual prevalence of disease, and even in the medical literature of the present day this epidemic constitution crops up occasionally in instances in which the mode of propagation has not been satisfactorily established. More time and intelligent labor have probably been given to meteorologic observations, with the view of throwing light on this subject, than have been expended on any other line of scientific research. For generations men have been observing and recording, but the collators have been few. Progress has indeed been made, but it has chiefly been by some of the sister sciences invading the domain of medical meteorology and dissipating some part of her clouds and uncertainties. A few years ago cholera was regarded as "obscure in its meteorological relations, modified by such conditions to a great extent, but never controlled by them" (Lorin Blodgett). Many of the agencies of epidemic diseases have been trailed to

their haunts, but those of typhus, yellow fever, small-pox, scarlet fever, and measles continue in their old-time obscurity; and the meteorological points connected with them are, briefly: Typhus emanations freely diluted with air are harmless; yellow fever disappears with the advent of frost, and the others have the colder months as their season of prevalence, probably because their contagia are concentrated and correspondingly pernicious in the close, unventilated rooms of that season.

Although the tendency of modern research is to absolve the air from any special complicity in the propagation of epidemic diseases, the charge of influencing the human system unfavorably still holds good in certain other respects. Alterations of atmospheric pressure have been regarded by some medical observers as causing pulmonary congestions, and both compressed and rarefied airs have been used in the treatment of diseased conditions of these organs. In hospitals for consumption, however, where any general influence causing congestion of the lungs would be manifested by an increase in the number of cases of hæmoptysis, careful observation has shown that there is no such increase during the passage of the storm centre. One medical writer of high repute insisted on the influence of air pressure on the healing of wounds, and urged the advisability of adding a portable barometer to the surgeon's equipment, that he might be enabled to perform all operations not of an emergency character, with the mercury at not less than 29.869 inches. The exacerbations of neuralgic and rheumatic pains coincident with alterations of atmospheric pressure have established a popular belief in their relations as effect and cause, which has received some support from a consideration of caisson disease.

The caisson for the Brooklyn tower of the East River Bridge measured 168 x 102 feet, its interior or working chambers being 14 feet in height. It was, in fact, a huge box sunk mouth downward by laying courses of concrete on its upper surface. Compressed air forced into the chambers displaced the water; and relays of men excavated the bottom of the river bed beneath it until a rock foundation was reached. The upper end of each shaft leading to the chambers was guarded by an air-lock to prevent injury to the men by a sudden change of pressure on entering or leaving. Before descending, compressed air from below was admitted gradually into the lock chamber, and only when the density was equal to that in the caisson was the descent made. Correspondingly, before leaving, a gradual transition from compressed to ordinary air was effected. On exposure to air under a pressure of three or four atmospheres, the skin became pale and shrivelled and the countenance shrunken, as the blood was forced from the superficial vessels to those of the bones and the cavity of the skull. The heart's action increased in rapidity to overcome the impediment to the circulation; but after a time the system accommodated itself to the altered conditions, and generally no bad effect was manifested until the men returned to the colder and relatively rarefied air of the surface, when many suffered from pains in the bones, giddiness, faintness, numbness, and even paralysis. A longer time in the lock chamber, to permit of accommodation to lessening air pressure, would no doubt have prevented these injurious effects.

The diminished pressure at high altitudes is described by travellers as causing *soroche*, or mountain sickness, which is characterized by restlessness, sleeplessness, gasping respiration, anxiety, vomiting, and fainting. It is experienced at a height of ten or twelve thousand feet when the individual is expending energy by climbing, but in balloon ascents the effects of diminished pressure are not felt until twice this distance has been reached.

Heat relaxes the tissues and depresses the vital energies. Cold stimulates these energies to make good the loss of animai heat; but if excessive it benumbs and paralyzes and ultimately destroys by freezing. When local in its application it disurbs the circulation of the blood, causing a congestion of some internal organ when the surface of the body is chilled and its vessels are contracted.

Air at 50° F. (10° C.) saturated with moisture is colder to the feel than dry air at the same temperature; it chills by contact. Above 50°, however, it is warmer, as it prevents evaporation from the body. At high atmospheric temperatures it is oppressive and induces heat exhaustion or sunstroke. As evaporation is stopped, the system is unable to keep down its heat to the normal of 98.4° F. (36.9° C.), and when the blood becomes heated higher than this, dangerous symptoms are developed.

The progress of cases of consumption is so manifestly affected by atmospheric changes that the disease until lately was regarded as originating in them. When it is fully established, the duration of life depends on the equability of the climate. Insular climates in warm latitudes are preferred; and the moist warm air of Florida and Southern California is much recommended by medical men. On the other hand, recovery is now generally conceded to be probable, if in the stage of invasion the patient will submit to live in an equable climate, with active exercise in the open air, preferably on horseback. The tablelands of the west and the mountains of New Mexico and Arizona have many records of recovery from consumption in its earlier stages.

Liquefaction of Air.—Ordinarily we think of air only as air, but it has been condensed to the liquid form and even solidified. Air becomes liquified at −140° C. (−220° F.) under a pressure of 39 atmospheres; but if the temperature is lowered beyond this, the pressure required to effect the liquefaction will be less. Faraday condensed a number of gases such as carbonic and sulphurous acids under pressure, but failed in all his efforts to liquefy oxygen by not associating a sufficiently low temperature with the pressure employed. Pictet succeeded in liquefying oxygen in 1877 by using the low temperature produced by the rapid evaporation of liquid sulphurous acid to liquefy ethylene, and thereafter employing the ethylene to reduce the temperature of the oxygen. This process was tedious and expensive; but in 1893 Charles E. Tripler, of New York, marked out a process for the production of liquid air on the manufacturing scale, in which the air was condensed to liquidity by the cold produced by its own expansion when liberated from under pressure. The air was compressed first under a pressure of 100 pounds per square inch, and was then passed through pipes surrounded with water to remove the heat liberated by the condensation. It was next subjected to a pressure of 800 pounds to the inch, and the heat developed was removed as before. Lastly, it was subjected to a pressure of 2,000 pounds per inch, and when cooled it was passed into coils of copper tubing which were jacketed with non-conducting material. The pressure within the coils was equal to about 15 atmospheres, while that in the jacket was only one atmosphere, so that when a minute aperture in each coil was opened, the compressed air escaped and expanded. The cold resulting from expansion was such that while two-thirds of the air operated on escaped as air, the remaining third became liquid and collected in the lower part of the cylinder jacket whence it could be drawn off like water from a spigot. It can be thus produced at the rate of two cents, or one English penny, per pound. So far, the study of liquid air has developed no suggestion of usefulness from the medical or hygienic standpoint, although it has proved a valuable instrument in scientific investigations. Mr. Tripler is endeavoring to utilize it commercially as an agent for the production of power, but according to Dr. Hampson in the *Scientific American* (July 1, 1899), it cannot supersede steam: "This pound, or pennyworth, of liquid air, expanding to the volume of thirteen cubic feet of air vapor at atmospheric pressure, will do a certain amount of work in an engine. Half a pound of water will also expand to thirteen cubic feet of steam at atmospheric pressure, and expanding from a smaller volume, will do more work than one pound of liquid air. But half a pound of steam, made in a good steam-raising apparatus, only costs one two-hundred and fortieth part of a penny. For equal quantities of power, therefore, liquid air is

mathematically more than two hundred and forty times as dear as steam, and practically the difficulties of handling it will make it compare more unfavorably still."

Chemical Constitution.—Formerly air was regarded as one of the elements. The advance of our knowledge into the arcana of nature is well illustrated by the progress made in the investigation of air during the past century. It is now known to be a composite substance; the properties of its constituents have been determined, their relations to animal and vegetable life have been discovered, and traces of accidental impurities swept up by its currents from the face of the earth have been detected and studied in their bearing on sanitary conditions. The atmosphere, according to the chemist, consists of a mixture of two gases, oxygen and nitrogen. The former is active in its properties, combining with many susceptible elements, and especially with the carbon and hydrogen of devitalized organic matter, constituting, according to the rapidity of the process, either oxidation or combustion, and, with the same elements in the living tissues of animals, constituting one of the essentials for the continuance of life. A certain small percentage of the oxygen of the air exists in the form of *ozone*, a peculiar modification of oxygen which, although much studied since first discovered by Schönbein in 1840, has yet to have its chemical and natural history fully written. Its nature is uncertain, but it is generally regarded as O_2O. The quantity present in the air cannot be determined, and even its existence is at times indicated with doubt by the iodized starch papers, which have been largely used for its detection, as they are affected by other matters, as nitrous acid and peroxide of hydrogen, occasionally present in the atmosphere. Iodized litmus papers have been shown by Dr. Fox to be of value as a qualitative test, and as indicating comparative quantities when known volumes of the air are aspirated over them. It is certain, however, that ozone has stronger affinities than ordinary oxygen, and that oxidation goes on more rapidly in its presence than in its absence. It undoubtedly destroys the volatile substances which are evolved during the putrefactive process. When foul organic odors are present, ozone is absent. Hence, when the presence of ozone is indicated by the test papers, the air is regarded as free from organic contaminations susceptible of oxidation. Animals exposed to ozone artificially produced suffer from irritation of the lungs. The diseases of these organs prevalent in cold weather have therefore been attributed to it. Not many years ago, medical meteorologists anticipated great practical good from the study of ozone, particularly in respect to influenza and cholera, the one associated with an excess, the other with a deficiency of this form of oxygen, but the discovery of the bacterial origin of these diseases has deprived them of this incentive to a continuance of their labors.

The nitrogen is regarded as negative, or passive, serving merely to moderate the activities of the oxygen by dilution. Mention, however, should be made of the recent discovery of the elementary substance argon by Lord Rayleigh and Professor Ramsey. Argon has characters similar to those of nitrogen; but as its uses in the economy of nature have not as yet been determined, it must be left for the present with the nitrogen, with which it has so long been associated.

In the atmosphere the chemist recognizes also the presence of small but varying quantities of other matters such as carbonic anhydride, ammonia, and watery vapor. The percentage composition of dry air is, by volume, 79 of nitrogen, 20.96 of oxygen, and .04 of carbonic anhydride; by weight the relative proportions of nitrogen and oxygen, are 76.99 and 23.01. Nitrogen is the lightest, carbonic anhydride is the heaviest; yet, on account of the constant motion of the atmosphere and the tendency of gases to diffuse, there is no separation into strata richer in nitrogen above and carbonic anhydride below. This power of diffusion possessed by gases is such that, in places where there is a continuous generation of carbonic anhydride, it does not accumulate unless it is confined as in a room, and even then it is diffused through the whole air of the room and not collected by its weight near the floor. The intermingling of gases by diffusion is shown by Pettenkofer's examination of the air over certain effervescing springs. Samples from the water level contained 70 per cent. of carbonic anhydride; from 40 inches above the water level, 2 per cent., and from 55 inches only 0.5 per cent. Hence little difference is found in the percentage composition of the free air, whether samples be taken from over the land or the ocean, from the sea level or from a high altitude.

The oxygen of the air varies but little from its average percentage, but the quantity of it taken into the lungs varies with the temperature and pressure. Much of the depressing effects of atmospheric heat is probably due to a want of oxygen in the expanded air. A cubic foot of sea-level air at 32° F. contains 132 grains of oxygen; at 100° F. it contains 116 grains, a reduction of 12 per cent. Again, the distress felt by mountain climbers (see page 150) and usually ascribed to lessened pressure, is probably due in great part to the lessened amount of oxygen inhaled. A cubic foot of air, at 60° F. and 30 inches of pressure, contains 124.6 grains of oxygen. The expansion under a barometric pressure of twenty inches, corresponding to a height of two miles, with the coincident contraction by a fall of temperature to 20° F., would reduce the oxygen in a cubic foot to 90 grains, a reduction of 28 per cent.

The carbonic anhydride, or carbon dioxide, CO_2, familiarly known as carbonic acid, is produced by the oxidation of carbon in dead and living tissues, and its percentage in air varies with the local causes which determine its production. Thus it is greater in the alleys and streets of a city than in the open country, and as this gas is soluble to some extent in water, its proportion varies with the hygrometric and other conditions, being greater in a damp atmosphere before rain has fallen than in the air of the same locality after the aqueous vapor has been precipitated. The air currents and the diffusive power tend to equalize the percentage, but as production is constant in some localities, the air of these must always show a relatively larger quantity of this gas than that of others remote from such sources. The proportion in the external air seldom exceeds 4 volumes in 10,000. De Saussure made many series of observations to determine the percentage under various conditions. The present writer, while investigating the ventilation of soldiers' quarters, at Fort Bridger, Wyoming, in 1874, found in the external air a gradual decrease, day by day, from 4.5 to 2.6 volumes per 10,000 as the season advanced, and the surface of the earth became covered with vigorous vegetation.

Carbonic acid is a product of combustion; it will therefore not support combustion. It is a product of respiration, therefore it will not support respiration. In mines, life is in danger when a candle will not burn. Because workmen in soda-water factories suffer no inconvenience in breathing an atmosphere containing as much as two per cent. of carbonic acid, many have supposed that this gas is not poisonous, but that, like water, it drowns fire and life alike by preventing the access of oxygen. Nevertheless experiments have shown it to be actively harmful. Animals breathing it along with as much oxygen as is present in the atmospheric air have the heart's action weakened even to fainting, and when man is the subject of the experiment, dulness of mind culminates in unconsciousness or stupor. This, however, is not of much practical importance, for the sources which furnish carbonic acid to the atmosphere generally yield with it other and more dangerous substances.

Ammonia is diffused from putrefactive processes in progress on the surface of the earth. It is also produced, in traces, from the nitrogen of the atmosphere by electric agency.

Its quantity is variable, but 0.1 mgm. in a cubic metre of air is a not unusual amount. This corresponds to a grain in about 23,000 cubic feet. Rain washes the ammonia from the air to the surface of the earth in

amounts varying from 0.2 to 0.5 part per million of the rain water. The improvement in fields which are permitted to lie fallow has been attributed to ammonia in the rainfall, but this ammonia is manifestly inadequate to account for the masses of vegetation which annually find nourishment in the soil. The ammonia originating on or in the soil during the decomposition of its organic matters is the source of the nitrogen which feeds the living plants. A trace only of this ammonia escapes into the air and is afterward washed down with the rain. Prior to its use by the vegetation which covers the surface of the earth, it is nitrified by bacteria which are everywhere present in the upper layers of the soil Some of the lower forms of vegetable life, such as certain algæ and bacteria, absorb nitrogen directly from the atmosphere. Some leguminous plants also fix atmospheric nitrogen in their tissues, but this is accomplished indirectly through the medium of parasitic bacteria found in nodules on their roots.

The ammonia of the air is condensed on exposed surfaces, and R. A. Smith has suggested that the quantity of ammonia deposited on a given surface in a given time may be taken as an exponent of the sanitary condition of the atmosphere. A glass or other surface which has been exposed for some time in an unventilated bedroom, when washed with pure water will show in the washings the presence of a readily determinable quantity of ammonia; but the attempt to demonstrate the relative purity of atmospheres by the quantity deposited on equal and similar surfaces in equal periods of exposure meets with failure unless the temperature, the hygrometric condition, and the air movement are the same in both instances. This concurrence of similar conditions is difficult, if not impossible, to obtain in practice.

Watery vapor is constant in its presence in the atmosphere, but, as we have already seen, in such varying quantities that it is viewed by many as an accidental constituent. Its importance, however, not only in the preservation of the purity of the atmosphere, but as a preservative of the vitality of all the organisms submerged in it, is so great that it must be regarded physiologically as an essential.

The air constituents which have been mentioned must be regarded, from the scientific and sanitary point of view, as individually essential to the constitution of the atmosphere. The oxygen is vital to animals, its quantity being preserved by the evolution from vegetation and the equilibrium established between these two kingdoms of nature. The carbonic acid is vital to vegetation, being the source of the carbon solidified in its tissues; its quantity is preserved by the evolution from animals and the retrogressive metamorphosis of the organic carbon of devitalized tissues.

Organic substances are those developed by the forces of life. They include all living bodies and those that have ceased to live, with many products of the life of the one and of the decay or decomposition of the other. With the infinite variety of animal and vegetable life constantly before us, it is needless to suggest the complex character of organic matters, but, notwithstanding this complexity, little more than the elements contained in air and water enter into their composition. Animal life depends on vegetable life for its sustenance directly, or in the case of carnivorous animals indirectly. Animals cannot combine the elementary bodies, but these are taken by plants and formed into organic substances, which animals are capable of utilizing as food. So complex are all vitalized substances that but for the preservative influence of their vitality, their molecules would speedily break up into simpler forms, and, indeed, when life ceases to protect them their putrefactive decomposition begins immediately and ends in their resolution into the very substances from which they were originally constructed. Nature moves in cycles. Day follows day and season season. The seed germinates and the grown plant matures its seed. Every generation is a cycle, and, in the instance before us, the elements from which life elaborated the highest organic structures revert to the inorganic condition of carbonic acid, ammonia or nitrates, and water for use in some succeeding cycle.

Even in the living organism similar changes take place. No machine works without wear. The tissues of the animal body are worn by exercise. The nitrogen of the worn-out tissues is removed by the kidneys as urea, which speedily becomes converted into ammonia, while the carbon is oxidized and the resulting carbonic acid is carried to the lungs to be expelled.

During quiet breathing twenty-seven cubic inches of air enter the lungs at each inspiration, and if the air be pure nearly six of these cubic inches are oxygen and only one one-hundredth part of a cubic inch carbonic acid. The air expired has less oxygen, more watery vapor, a taint of organic matter, and somewhat more than a cubic inch of carbon dioxide. Breathed air, therefore, contains a hundred times more carbon dioxide than is contained in an equal volume of the free atmosphere. The frequency and depth of the respiratory acts vary in the individual with his condition as to health, exercise, or repose; and as might be expected, they vary also in different individuals under the same or similar conditions. The average excretion of carbon dioxide by the human lungs can therefore be stated only approximately. Giving due consideration to the experimental results obtained by various qualified investigators, its amount may be stated to be at least 0.01 cubic foot per minute, 0.6 per hour, or 14.4 in the twenty-four hours. The energy of the vital actions concerned in respiration may be appreciated when we realize that in 14.4 cubic feet of this invisible gas we have nearly half a pound of solid carbon.

Although the inflow into the lungs is interrupted by expiration at comparatively regular intervals, the absorption of oxygen and evolution of carbon dioxide are continuously in progress. The inspiratory inflow of 27 cubic inches mixes with the air already in the lungs and freshens it for the use of the system. Deep breathing washes out the lungs and permeates them with an air rich in oxygen and comparatively free from carbonic acid. No matter how pure the surrounding air may be, an individual may suffer from impure air in his lungs if by sedentary habits, or other cause, his breathing becomes shallow and insufficient.

Allowing 16 as the average number of respirations per minute, with an air movement of 27 cubic inches into and out of the lungs, the air respired in an hour would measure 15 cubic feet and in twenty-four hours 360 cubic feet, and with an output of 0.01 cubic foot of carbon dioxide per minute the respired air would contain 4 per cent. of this gas. From these data may be calculated the amount of dilution needful to bring respired air back to a condition of purity approximating that of the free atmosphere. If 15 cubic feet of breathed air containing 0.6 of a cubic foot, or 4 per cent. of carbon dioxide, be uniformly mixed with 99 times its bulk of air containing no carbon dioxide, the 0.6 cubic foot of this gas present would constitute 0.04 per cent. of the mixture; but in using atmospheric air for the dilution the percentage of carbon dioxide in the resulting 1,500 cubic feet would be nearly 0.08, inasmuch as each cubic foot of the diluting air brings with it the 0.04 per cent. of this gas which it naturally contains. But as the organic taint in respired air which has been diluted to this extent is perceptible by its odor to one entering from the fresh air, it is evident that this dilution is insufficient. Even when the carbon dioxide is diluted to 0.07 per cent., sensitive nostrils can detect the presence of the associated organic matter; but if the 1,500 cubic feet containing 0.8 per cent. be further diluted with an equal volume of fresh air containing 0.04 per cent. of carbonic acid, the mixture is reduced to 0.06 or six volumes in 10,000 volumes of the air, and with this dilution of 3,000 cubic feet per hour per person, sanitarians are satisfied, except in the case of certain hospitals.

It is easier to pass 3,000 cubic feet of air without creating coldness or draughts through a large cubic space per man than through a small one. If a room give only 300 cubic feet per man, its air has to be changed ten times in an hour to supply the 3,000 cubic feet of ven-

tilation. If it give 1,000 cubic feet per man, the air has to be changed only three times. A linear inflow of less than two feet per second is imperceptible. With two feet of current air the area of the inflow to deliver the 3,000 cubic feet would be 60 square inches.

The amount of carbonic acid in a sample of air is determined by adding a known quantity of lime or baryta water to the air in a large glass bottle or jar, and thereafter finding how much of the hydroxide has been converted into carbonate. The practical details are as follows:

Make an oxalic acid solution (2.864 per litre or $10\frac{n}{10}$ oxalic acid + 12 Aq.), 1 c.c. of which is equivalent to 1 mgm. CO_2. Make also a caustic baryta or lime solution of equivalent strength. Transfer the alkaline solution for storage until required for use to small bottles each holding about 60 c.c. (two-ounce vials), each of which is corked securely and weighed, and the total weight of the bottle and its contents marked upon the label. The air to be examined is collected in a clean and perfectly dry glass bottle or narrow-mouthed jar, of known capacity. Ten-litre bottles are large enough to give accurate results. A small bellows with a rubber tube on its nozzle is conveniently used in filling the jar with the air to be examined, but care must be taken that the air entering by the valve of the bellows is not contaminated by any direct respiratory streams from individuals present. As soon as the change of air has been effected, one of the prepared baryta vials is uncorked and its contents poured into the jar, which is then closed by an accurately ground stopper, or preferably by a tightly fitting rubber cork. The baryta solution is then shaken in the jar, and made to flow all over its interior to promote its contact with the contained air; but to insure thorough absorption of the carbonic acid the jar is usually permitted to stand until the following day before determining the loss of alkalinity. Meanwhile the volume of the air operated on is ascertained from observations made at the time the air was collected. The height of the barometer and of the dry and wet bulb thermometers or the dew point must be known, as well as the quantity of bartya solution introduced into the jar. The last is obtained by weighing the now empty vial in which it was stored and deducting this weight from the gross weight marked on the label. The quantity in grammes of the baryta solution employed must be deducted as cubic centimetres from the known capacity of the jar. But in order that the experimental results may be susceptible of comparison, it is necessary to express the air volume in the space which it would occupy when dry at 0° Centigrade and under a pressure of 760 mm. of mercury. Increased pressure diminishes the volume of air, increased temperature expands it; and the pressure of the watery vapor present must also be taken into account. The temperature observations furnish the dew point, and through it, from the observations of Regnault, the pressure or tension of the aqueous vapor may be obtained. If p represents this pressure, t, the temperature in Centigrade degrees, b the barometric height in millimetres, and V the capacity of the jar, minus the number of cubic centimetres of baryta solution introduced, the corrected volume will be equal to

$$\frac{V\,(b-p)\,273}{(273+t)\,760}$$

If the observations have been made on Fahrenheit's scale and in barometric inches the formula is:

$$\frac{V\,(b-p)\,491}{29.92\,(491+dt)}$$

in which dt is the number of degrees between 32° F. and the observed temperature.

When baryta solution is used to absorb the carbonic acid, the action may be considered completed in half an hour; but with lime water it is better to suspend further proceedings until next day. Then take, say, 20 c.c. from the jar, add phenolphthalein, and drop in the oxalic solution from a burette until the color is discharged. The loss of alkalinity in cubic centimetres = milligrams of CO_2 in the 20 c.c. of the solution tested, from which the CO_2 absorbed by the whole of the baryta solution may be calculated = milligrams of CO_2 in the air collected. Convert weight of CO_2 into volume by multiplying by 0.573, and for purposes of comparison calculate it into volumes per 10,000 of the corrected air. It must be mentioned, however, that the volume of carbonic acid found by this experiment is not all carbonic impurity, but includes that which is naturally present in the atmosphere. When the result of a contemporaneous experiment on the external air has been deducted from it, the remainder will indicate the carbonic impurity or the carbonic acid due to imperfect ventilation.

An easily applied method of ascertaining whether a given air contains more than a certain number of volumes of carbonic acid per ten thousand is based on the turbidity caused in lime water by the precipitated carbonate. If a half-ounce of this liquid is shaken up in an eight-ounce vial filled with the air to be examined, the appearance of turbidity indicates the presence of eight or more volumes of carbonic acid in ten thousand volumes of the air, and that the arrangements for ventilation in the apartments which furnished the air are not as satisfactory as could be wished. Bottles of various sizes are used by the operator conducting this, *the household method of sanitary air analysis*, and from the capacity of the bottle in which a just visible turbidity is produced the volumes of carbonic acid per ten thousand become known.

In another method, the *minimetric*, air is introduced in small quantity into a vial containing lime or baryta solution, which is well shaken, with gradual additions of the air, until the liquid shows a certain loss of transparency, when the carbonic acid is calculated from the quantity of air needful to the production of this result.

These, although pretty experiments, and described in full by most sanitary writers, have not come into general use, because they are not required. As they yield results which are only approximative, they cannot take the place of the accurate determination needful in a scientific inquiry, while, as rough-and-ready methods, their results convey no more information of practical value than may be gathered unpretentiously by the sense of smell. A well-ventilated room should not have more than one or two volumes per ten thousand in excess of the external air, equalling a total of five or six volumes. When the carbonic acid amounts to seven volumes, a want of freshness is recognized on entering. When nine, ten, or more volumes are present, the organic odor becomes manifest.

Although the carbonic acid, as has been stated, is generally accepted as a measure of the respiratory impurity, it is not an accurate one, for it is more readily diffused and carried off by ventilating current than the organic exhalations which accompany it from the human system. Whence it comes that the continued occupancy of an apartment may give rise to organic odors in its atmosphere, although carbonic acid may not be present in large quantity. The exhalation appears to adhere to walls and other surfaces, and textures, and to require time for its dissipation.

But, while the carbonic acid is not an accurate measure of the organic contamination in the air of occupied buildings, its estimation affords the best means of testing *the efficiency of the ventilation*. Sanitary inspectors do not recognize this fact. Sanitary chemists have not brought it prominently into notice. When questions of ventilation are to be settled, Cassela's air meter is used, and the air movement is calculated from its indications and the areas of inflow and exit. The inspector shows that so much air has entered or that so much has escaped, to be replaced of necessity by a corresponding volume of fresh air through the inflow ducts. But this is not enough. It must be shown that the air introduced has effected the purpose for which it was introduced. This may be done by a calculation based on the amount of carbonic impurity found by experiment. The capacity

of the room must be ascertained, and in exact calculations deduction should be made for the body bulk of the occupants and for the furniture. The time during which the deterioration has been going on is another factor entering into the calculation.

The carbonic evolution, 0.01 cubic foot per minute or 0.6 per hour per person, multiplied by the number of minutes or hours, gives the amount of the carbonic impurity expired. When this is divided by the carbonic impurity found by experiment in ten thousand volumes of the air, the quotient multiplied by ten thousand will express, in cubic feet, the volume of the air with which the respiratory products have been diluted. But, as the air volume in the room has contributed to the dilution, its capacity has to be deducted from the total to obtain the amount of the inflow. Thus, if the data consist of 20 persons, 3 hours in a room having a capacity of 10,000 cubic feet, the air on analysis showing 14.5 volumes or a respiratory impurity of 11 volumes, as a parallel experiment on the external air indicates the presence of 3.5 volumes.

$.6 \times 20 \times 3 = 36$ cubic feet of carbonic acid expired.

$11 : 10{,}000 :: 36 : 32{,}727$ cubic feet of air concerned in the dilution.

$32{,}727 - 10{,}000$ in room $= 22{,}727$ inflow.

$22{,}727 \div 3 = 7{,}576$ cubic feet inflow per hour.

$7{,}576 \div 20 = 379$ cubic feet per hour per person.

In practice it is often found that the inflow, as determined by the anemometer, is much greater than that obtained from the chemical results. That the air enters is certain, and that it fails to be utilized in diluting the expired air is equally so. In one of the schools of Washington, D. C., 800 cubic feet per minute entered the room, while but 324 cubic feet contributed to the ventilation. The cause in this instance was manifest. The temperature of the inflow was so great that the air rose immediately to the ceiling, whence it was drawn off by the lowered windows and foul-air flues.

Impurities in Air.—Carbonic acid in air, while essential to vegetable life, must be regarded as an accidental impurity in its relations to animal life when present in any locality in excess of that found in the free atmosphere. The sources from which the carbonic acid is derived often yield with it other and more dangerous substances. These sources are, first, combustion for artificial warmth and lighting; second, the resolution or dissipation of dead organic matter, and, third, the resolution or dissipation of the tissues of living animals by the respiratory process.

Products of imperfect oxidation are associated with the carbon dioxide from the combustion of fuel. A lamp or fire smokes and smells when its oxygen or air supply is insufficient. The smoke is unoxidized carbon and the smell an emanation from transition products. The dangerous product in the combustion of fuel is carbon monoxide. This colorless and inodorous gas is highly poisonous, entering the blood and rendering the red corpuscles incapable of performing their functions even though pure air be afterward supplied. Death is the result of asphyxia. In rooms heated by stoves the headache, languor, and oppression occasionally produced are due to the escape of this with other gaseous products through the open stove doors, leaky joints, and turned dampers. Some experiments of St. Claire Deville and Troost indicated that the carbon monoxide might even pass through the pores of cast iron when the metal became strongly heated. The French Academy, therefore, caused an investigation to be made of this subject, and the conclusion was reached that this dangerous gas does pass through the metal when its temperature reaches a dark-red heat. Since these experiments, air heated by furnaces or cast-iron stoves has been regarded as injurious. But doubt has been thrown upon the results of the French chemists by several later experimenters, and particularly by Professor Remsen, who has shown some possible sources of error, and who, having guarded against these, has concluded that, while carbon monoxide may be present in the air of furnace-heated rooms, it must exist in quantities so minute that it is questionable if it can act injuriously on the health of those who breathe it.

The deadly nature of *water gas* as compared with coal gas is due to its larger proportion of carbon monoxide. Coal gas contains less than ten per cent., while water gas contains thirty to forty per cent. Water gas is manufactured by playing steam on glowing coke or charcoal, the products being carbon dioxide, carbon monoxide, and hydrogen. The number of deaths from leakage of gas has been greatly increased since the introduction of water gas. Where one death was formerly reported in a given time and population, there are now twenty-five to thirty deaths.

In connection with local accumulations of these gases it should be remembered that they are explosive when mixed with air. It is therefore dangerous to strike a light in the room of a gas suicide or to look for a gas leak in a cellar or basement until after some ventilation has been effected. A mixture of one gas to eight air is most violent in its explosion. With one to four there is not enough air for explosion, and with one to twelve there is not enough gas.

The evolution of carbonic acid into the air of a room during the combustion of illuminating gas or oil is generally underestimated in considering the carbonic impurity of occupied rooms. Parkes states that one cubic foot of gas consumed in an hour produces as much as the respiration of one person. One oil burner consuming four ounces of illuminating oil per hour is allowed in United States barracks for every ten soldiers. The oil consumed pervades the barrack room with somewhat more carbonic acid than is expired by the ten men. The necessity for increased ventilation must be considered with the presence of each lamp or gas jet.

Carbureted hydrogen and sulphurous acid are liberated during combustion, but in such small quantities that they need not be considered as affecting health.

Associated with the carbon dioxide derived from the oxidation of the carbon of dead and decomposing organic matters on the surface of the earth, sometimes aggregated locally into manure piles, cesspools, vaults, drains, and sewers, are certain compounds intermediate in composition between the complex organic matter in process of putrefaction and the simply constituted organic substances which are the result of the completed oxidation. The sulphur present in certain tissues becomes converted into hydrogen or ammonium sulphide, while among the nitrogenous products are many foul-smelling and harmful gases and vapors of an ammoniacal character; hydrocarbons also are formed. Formerly the reversion of organic matter to the inorganic condition was supposed to be due to the purely chemical process of oxidation by the oxygen of the air. Decomposition was regarded as a slow oxidation at a low temperature, as combustion was a rapid oxidation at a high temperature; but when Pasteur showed that meat could be preserved from putrefaction when exposed to the air, provided the air was first filtered through cotton wool, this chemical theory of decomposition had to be abandoned. Ultimately the saprophytic bacteria were discovered, and now these are recognized as so universally present and so essential to the disposal of organic matter that they cannot be regarded as an impurity in the air. They are the means to an end, one of the great links in the endless chain of life, and as important in the wonderful scheme of creation as the carbon dioxide which they prepare for the future growth of vegetation.

The action of the sulphur gases on the animal system has been demonstrated experimentally by Barker on dogs and other small animals. Hydrogen sulphide produces vomiting and diarrhœa, prostration and coma, which, like the effects of carbon monoxide, persist after removal from the contaminated atmosphere. The exhaustion and coma continue, and death results if the impression fixed on the blood is sufficiently powerful. But, while this occurred in the subjects of Dr. Barker's experiments, it is well known that men may breathe with

impunity for a time a sulphureted atmosphere many times stronger than those employed by him. Ammonium sulphide, according to this experimenter, caused vomiting and febrile action, quickly followed by the development of a typhoid condition. In fact, he considered the hydrogen sulphide similar in its action to the poison of typhus, and ammonium sulphide to that of typhoid fever.

Chronic poisoning by hydrogen sulphide manifests itself, according to some observations, by gradual prostration, emaciation, and anæmia, with headache, foul tongue, anorexia, and the occasional eruption of boils, but it is not certain that these symptoms are due to this gas and not to organic vapors which accompany it.

The action of the more *complex organic vapors* given off during decomposition has not been determined. The dogs subjected by Dr. Barker to cesspool air were all more or less affected, the symptoms being those of intestinal derangement with prostration, heat of surface, distaste for food, and those general signs which mark the milder forms of continued fever common to "the dirty and ill-ventilated homes of the lower classes of the community." But the sulphur compounds already mentioned contributed to these results.

Even the constitution of these organic vapors is not known with certainty. Dr. Odling distilled half a gallon of the liquid contents of a cesspool until all volatile matters had come over. He treated the fetid ammoniacal distillate with hydrochloric acid, and afterward precipitated with platinum. The platinochlorides of the organic alkalies were found to crystallize in well-defined, flattened, orange-colored tablets, evidently not the platinochloride of ammonium. Incineration of this platinum salt yielded 41.30 per cent. of the metal, while the platinochlorides of ammonium, methylamine, and ethylamine gave respectively, 44.36, 41.64, and 39.40 per cent. of platinum. The salt formed from the *carbo-ammoniacal vapors* was analogous in composition to that formed with methylamine. But inasmuch as the crystals were more like those of the ethyl salt, and as a mixture of the ethylamine and ammonium salts would correspond in percentage composition to that obtained from the distillate, he supposed that the sewage emanations were ammoniacal and ethylic.

A series of experiments made by the writer has shown that the volatile matters evolved during the fermentative changes in organic substances are of two different characters, the one vaporous and ethylic, but not containing nitrogen if separated from the ammonia with which it is volatilized and condensed, and the other volatile, carbonaceous, and solid, concreting on distillation into white, soft, and greasy particles. The former has a dull, mawkish, not positively unpleasant, odor, the latter a strong and intensely disagreeable smell.

Marsh gas, a colorless, inodorous, and, fortunately, non-poisonous gas, is largely formed as a transition product in the decomposition of vegetable matter. It is evolved in the gradual transformation of wood into coal, constituting in mines the "fire damp" which is the occasion of so many disastrous explosions. It explodes, in the presence of flame, when forming only one-eighteenth of the air of the mine. The resulting gases, carbon dioxide, nitrogen, and vapor of water, constitute the "after damp" or "choke damp" which suffocates those miners who have not been killed outright by the explosion.

Associated with the carbon dioxide of respiration are certain organic exhalations which differ in constitution, according to the efficiency or imperfection of the oxidation in the tissues. In diseased conditions of the body these exhalations are thrown out in greater quantity than in health and the infection of disease in some instances accompanies them. They are exhaled not only from the lungs, but also along with the perspiration from the pores of the skin. The quantity of organic matter thus eliminated has not been determined, but is known to be small. It does not diffuse like a gas into the atmosphere, but floats, when there are no currents to disturb it, like an odorous but invisible cloud. If evolved into the air of a close room its amount is proportioned to that of the carbon dioxide exhaled by the occupants, in the absence, of course, of any other output of this gas. As vapor of water is deposited from a saturated air, so these organic clouds become similarly condensed on walls, furniture, hangings, bedding, clothing, and other exposed articles. In a room saturated with organic exhalations the mere renewal of the air does not dissipate the taint, for the renewed air becomes immediately affected by the volatilization of the organic deposits. The necessity for a thorough aeration is obvious.

The evil effects of breathing respired air are attributed to these organic matters. Many experiments have been made on this subject, the most striking of which are those by Brown-Séquard and d'Arsonval, reported in 1889. They connected a series of four air-tight cages by means of rubber tubing and aspirated a steady current of air through them. In each cage was a rabbit. The animal in the last cage of the series breathed the air which contained the respiratory products of the animals in the other cages, while the animal in the first cage was supplied with pure air. After a time the animal in the last cage died as a result of its confinement in the impure air, and a few hours later that in the cage next to the last also succumbed. The inmates of the first and second cages survived. On placing an absorption tube between the third and fourth cages, the animal in the last cage survived the experiment, while that in the third cage died. This seemed to indicate that the toxic substance in the air was destroyed by the sulphuric acid and was therefore probably organic matter. These experiments were repeated, with the same results, by Merkel in 1892. In a Smithsonian contribution, however, by Drs. Billings and S. W. Mitchell, published in 1895, it is contended from some experiments made under their direction that in the air expired by healthy mice, rabbits, etc., there is no peculiar organic matter which is poisonous to the animals mentioned, or which tends to produce in them any special form of disease, and that it is very improbable that the minute quantity of organic matter contained in the air expired from human lungs has any deleterious influence upon persons who inhale it in ordinary rooms. They concluded also that the discomfort produced by crowded, ill-ventilated rooms in persons not accustomed to them is not due to excess of carbonic acid, nor to bacteria, nor in most cases to dusts of any kind, the two great causes of such discomfort being excessive temperature and unpleasant odors. These odors, it is said, may in part be due to volatile products of decomposition contained in the expired air of persons having decayed teeth, foul mouths, or certain disorders of the digestive apparatus, and they are due in part to volatile fatty acids given off with, or produced from, the excretions of the skin, and from clothing soiled with such excretions. They may produce nausea and other disagreeable sensations in specially susceptible persons, but most men soon become accustomed to them and cease to notice them, as they will do with regard to the odor of a smoking car or of a soap factory after they have been for some time in the place.

There are no micro-organisms in the air in the lungs. They are filtered out of the inspired air, or captured in mucus and ciliated out before they can reach the pulmonary cells. We know this to be the case because when there is no break in the skin in an injury to the lung from a fractured rib, we may have emphysema and pneumothorax with hemorrhage, but no pleurisy. Besides this, Tyndall showed by the electric beam the freedom of the expired air from particulate matter.

But that evil consequences do follow overcrowding and its necessarily vitiated air is well known. Every schoolboy knows the history of the Black Hole of Calcutta. The typhus fever which formerly ravaged the tenements of cities and the prisons, barracks, camps, and ships of all nations, is recognized as having been propagated by the noisome exhalations in unventilated and overcrowded quarters. Indeed, it may be said that not only has typhus fever been banished from civilized com

munities, but that the malignancy of many and the prevalence of all the infectious diseases have been lessened by a recognition of their connection with organic exhalations from the human body.

But evil consequences of a lighter grade are also recognized as the legitimate offspring of vitiated air. The breathing of air that has already been breathed gives rise in succession to feelings of languor and heaviness, headache, dulness of mind, drowsiness, dizziness and faintness, sometimes nausea and, if continued, feverishness. These symptoms indicate a poisoning of the blood by organic matters which would not be present in it with free supplies of air to wash them away. The brain is the first of the organs to feel the effects of the tainted blood. The mental inaptitude of children after two or three hours in a close schoolroom is easily understood. The waste organic matters retained in the blood are not necessarily absorbed from the contaminated air. They may be due in great part to a suppression of the regular exhalations and a consequent retention of matters which ought to have been exhaled. As with moisture in air so with these organic exhalations. The air when saturated refuses to take up more. Again, their retention in the blood interferes with the oxidation which should go on in the tissues; and the transition products that are formed, being also retained, add seriously to the disordered condition. The individual becomes poisoned by products of his own living processes.

The human system, however, appears to accommodate itself to a certain degree of impurity in the air, so that, after a time, the breathing of such air ceases to occasion the feelings of acute discomfort that have been mentioned. But in their stead a depressed condition of the system is developed, manifested by pallor of countenance and loss of appetite, strength, and spirits. The vitality of the individual is lessened. Every draught becomes dangerous to him, and even the chill from a wall or closed window may cause serious sickness. He becomes a ready victim to consumption if the germ of that disease is present, as is so frequently the case in the crowded dwellings of the poor in our large cities. Health, in fact, becomes broken and the nervous system prostrated, a condition in which a resort to alcoholic stimulants often gives temporary relief at the expense of a more rapidly fatal issue.

Besides the gases and vapors already mentioned there are many particulate bodies, living and dead, organic and mineral, floating in the atmosphere. All are accidental and therefore impurities. A few years ago, Professor Tyndall made use of an electric beam as a searchlight for floating particles. In pure air, made so by specially filtering it, the track of the ray is invisible, but in the free atmosphere it is defined with more or less brightness by reflection from particles ordinarily invisible. If the electric beam were passed through the air of many of our rooms, we would hesitate to inhale the aerial turbidity which it would reveal. The lower strata of the air are filled with such impurities, but air at a height of six hundred feet is comparatively pure in this respect. The smoke clouds, consisting of particles of unburned carbon which hover over manufacturing cities, seldom rise higher than this.

It is impossible to do more than outline these floating particles in the most general way, because everything on the face of the earth is susceptible of being ground into dust and of being swept up by atmospheric currents. Matters, indeed, of an extra-terrestrial origin are present in the form of dust derived from the destruction of meteors in their passage through the atmosphere. The inorganic dust consists chiefly of carbon particles, amorphous silicates, irregular fragments of hard mineral substances, and salts of lime, potash, soda, and ammonia. The organic dust includes the detritus of decaying vegetation, starch cells, epidermal hairs, filaments from the pappus of the Compositæ, pollen grains, and disintegrated woody tissue. The animal kingdom also is represented in the dust by fibres of wool, plumlets of feathers, butterfly scales, and other débris of insect life, together with occasionally epidermal and epithelial scales. Saprophytic bacteria are present, and in certain localities pathogenic bacteria, as the bacilli of tuberculosis, bubonic plague, pneumonia, etc. Locality and season influence the quantity and character of these impurities. Naturally air which blows over a long stretch of land contains more than sea air. Cotton is found in nearly every sample of autumnal air in the Southern States. Pollen grains, on many occasions, have given a yellow color to the rainfall. Autumnal catarrh, sometimes called hay fever, which affects so many people at a certain period of the year, is attributed by most medical men to this impurity. Susceptible individuals avoid attack by getting away from the pollen-laden air. Crystals of sodium chloride are notably present in the air of the seacoast, while in that of cities we find carbon particles and crystals of ammonium sulphate from the combustion of coal. The air of houses contains fragments of the fibres of clothing and epidermal scales, while that of hospitals, workshops, factories, mines, etc., is charged with particles varying in character with the occupancy and work. Sand and other mineral substances are irritant from their hardness and angularity. They induce irritation of the eyes and air passages, predisposing to consumption and pneumonia. Workmen in the dust-producing trades, such as stone-cutters, steel-grinders, potters, etc., frequently suffer from lung diseases. Sanitarians have given earnest attention to this subject with a view to lessening sickness and mortality.

But in many instances, according to the nature of the mineral particles, effects are produced other than those due to their physical characters. Lead-miners and painters are liable to colic, wrist drop, and serious disease of the brain from the absorption of the inhaled particles into the blood. In this instance, as in all atmospheres contaminated with absorbable matters, the evil arises not alone from that which is inhaled, but as well from that taken into the mouth and swallowed either directly from the air or by eating with unwashed hands which are tainted with the dust. Arsenical dust also is injurious when inhaled or swallowed, and not only do the workers in arsenical pigments suffer, but many of those who live in rooms lined with arsenical wallpaper.

Sometimes the inorganic matters pervade the atmosphere of localities in the form of vapor, as in factories where phosphorus or mercury is in constant use.

The earliest observations on the impurities of air were made on condensations gathered from the outside of a vessel containing ice. Subsequently experiments were made on water which had been shaken with successive volumes of air. In both cases a liquid was obtained which putrified readily and in which the presence of living organisms could be identified. R. A. Smith was perhaps the first to use the latter method. He put one hundred and fifty drops of pure water in a small vial containing air from a cow stable. He shook the bottle that the water might entangle and wash out all particles of solid matter from the air. He renewed the air; and this he did five hundred times. When he examined the water under the microscope, he was astonished at the immense number of spores which were visible, along with many other matters organic and mineral; and afterward many animalcules of various kinds were developed in it.

At the present time aerial organic matter is investigated microscopically, biologically, and chemically. Solid particles for microscopic study are caught on a glass slide lightly coated with glycerin. The general characters of atmospheric impurities may be ascertained by an examination of the rain or snow, for all those impurities that are not dissolved or absorbed by the rain are washed down by it. But for evaporation, condensation, and rainfall, the inhabitants of the earth would speedily be stifled in the dust swept up by the atmospheric currents. Distant objects, hazy and indistinct in a dry summer air, become sharply outlined in a purified rain-washed atmosphere. In rain water suspended impurities may be seen with the naked eye, and in the gradual melting of a pure white mantle of snow the stain made by its entangled

impurities will appear before it has shrunk to half its original thickness.

The biological examination resolves itself into a determination of the number of bacterial colonies and other micro-organisms in a given volume of the air, with culture experiments for the study of species. Official observations at the Montsouris Observatory near Paris, France, have shown that there are few bacteria in the air in winter, and that the numbers increase through spring and summer to over one hundred per cubic metre in the autumn. The air of city streets is densely charged with bacteria. The atmosphere is purer in this respect in its upper strata; air collected at over six thousand feet is practically free from bacteria and moulds.

Chemistry has done but little to perfect the organic analysis of air. With known methods of analysis the results obtained by the expenditure of much time and care are of small value. If an air specimen contains an unusual amount of the organic elements, it may be correctly considered as impure, but the nature of the impurity is not defined. The carbon estimated may have been a harmless particle of soot, or in part it may have been essential to the spread of a deadly disease. Nevertheless, analyses are made as a matter of official routine by sanitary officers in England and France. The organic substances are absorbed by aspirating large volumes of the air through a small volume of distilled water, and the liquid menstruum is then investigated by the processes of water analysis. Professor Remsen, of the Johns Hopkins University, Baltimore, Md., endeavored to improve on this process by filtering the air through powdered and moistened pumice before passing it in fine bubbles through the distilled water. He thus showed that, so far as could be determined by chemical means, all nitrogenous matter was retained by the filter. But, as germs or microscopic organisms might have passed through without thus showing their presence in the absorbing liquid, owing to the necessarily minute trace of nitrogen in them, the present writer carried out a series of experiments which determined, first, that the nitrogenous matter of air, excluding ammonia from consideration, is particulate; second, that it consists in large part of micro-organisms; and third, that filtration through Austrian glass wool effects their removal from the passing air. The experiments were conducted in a sterilized apparatus. The air was drawn through a short glass tube 1 cm. in diameter, lightly packed for two or three inches of its length with the glass wool. From this it was passed in fine division through distilled water. After this it was mixed with steam generated from a dilute solution of alkaline permanganate of potash, the mixture immediately entering the tube of a Liebig's condenser, where the steam was deposited, carrying down with it, after nature's process of air purification by the rainfall, any micro-organisms which might have escaped removal by filtration or absorption. The difficulties in the way of sterilizing the various parts of this apparatus were such that the first experiments, which gave speedy developments in culture liquids tainted by the filter, the absorbing liquid, and the condensate, were regarded only as the practical expression of these difficulties. The experiments were repeated with precautions suggested as necessary by the previous experience, and ultimately success attended them.

One of the processes of water analysis to which these matters were subjected involved the distillation of the ammonia which was present in the liquid, and its estimation by the calorimetric method with Nessler's solution. Ammonia gives, with this test solution, a faint straw-yellow color, which deepens, in proportion to the amount of ammonia present, to a dark sherry brown, or to a dark haziness or distinct precipitate. But it not unfrequently happened that in testing for ammonia in the distillate from the pure water in which the glass wool containing the organic matter of the air was suspended, as well as in that from the absorbing liquid which contained most of the ammonia, and in that from the condensate which contained but a trace, a citron-green color was produced which masked the ammonia reaction and rendered its estimation impossible. Dr. Kidder, of the navy, observed this interference with the ammonia coloration, and attributed it to the presence of substances evolved in the putrefaction of organic matter. He concluded from the few experiments he made that the amines are not necessarily concerned in its production, as he found that butyric acid gave a somewhat similar interference to that met with in the experiments on air washings. But the haziness with which the presence of butyric acid masks the true ammonia color is not the citron-green coloration which so frequently occurs in the analysis of foul airs. This is due to the presence of an ethyl compound which is given off from the carbohydrates while undergoing change. It may be obtained free from the ammonia which ordinarily accompanies it and obscures its reaction by submitting the liquid containing both to the process of nitrification. It may also be obtained from ammonia and free glucose, and from starch, cane sugar, tannin, salicin, etc., after treatment with heat and acids (see *Water Analysis*).

In some of the experiments referred to, an air volume of 100 litres was passed through the interior of a glass globe which contained liquid sewage and silt, garbage, or other foul and decomposing materials, and then through the glass-wool filter, absorber, and condenser to remove the matters with which it had become contaminated. Culture experiments showed the satisfactory removal by the filter of all germs and nitrogenous matters, ammonia excepted, and chemical tests determined approximately the quantity of organic matter thus removed. In some instances a second air volume of 100 litres was drawn over the organic matter in the globe, and the results obtained from the filter through which it was afterward passed did not differ from those of the first experiment on the same organic matter. From these experiments the conclusion appears admissible that the volume of air which is contaminated by a certain decomposing organic mass is the volume which comes in contact with it. If no air is drawn through the foul globe, only that which is contained in it is rendered impure. This air has its oxygen in time replaced by the foul-smelling gases of decomposition. Evaporation takes place from the contained liquid until the stagnant and enclosed air becomes saturated. The ascensional force of evaporation carries from the smeared and half-dried sides of the globe, and from the unsubmerged solids within it, some of the innumerable micro-organisms with which they are pervaded, and the air becomes charged with organic particles to an extent proportioned to its temperature and hygrometric condition. If a volume of air is drawn through the globe, it will be contaminated by organic matters carried away by its own movement and by the increased activity of evaporation produced by it. If a second volume is drawn through, it will be contaminated in like manner, and to the same extent, if the volume, rapidity of passage, temperature, and hygrometric condition are the same in both instances; and so for a third, a fourth, or more volumes, until the decomposing mass has become changed by their agency. This is recognized practically in sanitary work. The dead are buried that their decomposition may not contaminate the atmosphere. For the same reason garbage is collected and removed. A receptacle for foul-smelling and fermenting matters is less of a nuisance and less dangerous to health when fitted with an air-tight cover than when freely exposed to the air, for in the latter case every volume of air which comes in contact with it is a volume of air polluted. Sanitary officials in growing cities protest against the continued existence of small surface streams which of necessity pass into the condition of open sewers, tainting every volume of air which comes in contact with their foulness. These are bricked over and the air is preserved from the impure contact. But in the construction of regular systems of sewerage provision is made for this contact under the name of ventilation. The sewers are tapped at regular intervals along the streets for the exit of the contaminated air. From

the present point of view this *ventilation of the sewers* is of questionable benefit. The volume of air rendered impure, and possibly dangerous, is proportioned to the thoroughness of the ventilation. Sulphureted gases may be diluted, and the outflowing air be free from disagreeable odors, but the very air movement which effects this may raise invisible clouds of fermentative and morbific agencies from the foul interior. Experiments on this point would be of value. Those mentioned above indicate that the communication with the outer air should only be such as is needful to relieve tension and prevent the forcing of seals, and that these air holes should be guarded by some filtering material. But since the volume of air which becomes contaminated is that which comes in contact with the fermenting material, it may be reduced as well by diminishing the extent of the impure surface as by cutting off the ventilation. Hence sewers of small size, as in what is known as the separate system, are to be preferred, on sanitary grounds, to the large ramifying tunnels of the combined system. The foul airs which arise from sewer apertures are matters of every-day observation. If well diluted with air they may not affect the sense of smell, but they rise, nevertheless, from the grated covers on our streets, and may be seen, by the vapor precipitated from them, as an uprising column in weather which clouds the air of respiration thrown out from the lungs. With open streets and lively breezes it is probable that these exhalations are dissipated, or rather diluted, to harmlessness, but in enclosed spaces and stagnant atmospheres the sewer air, which is so carefully excluded from living rooms by intelligent plumbing, may enter as fresh air through open windows and apertures specially devised for its admission.

Sewer air is atmospheric air with its oxygen diminished and its carbonic acid increased to from ten to fifty volumes per ten thousand, and with taints or notable amounts of marsh gas, hydrogen sulphide, ammonium sulphide, and amines or compound ammonias in which one or more atoms of hydrogen are replaced by a positive radicle, methyl, ethyl, amyl, etc. Cesspool air has an excess of these foul-smelling constituents, for the contents of a cesspool continue to putrefy, while the sewage in a well-constructed system of sewerage should be carried away before putrefaction sets in. Each of the impurities in sewer air is harmful when breathed in strength, but not specially dangerous when diluted with atmospheric air, for it is well known that men whose occupations bring them into contact with this contaminated air do not suffer specially from disease. But sewer air, like respired air, contains organic matter, and the propagation of certain infectious diseases, particularly typhoid fever, has been attributed to the presence of their causative agencies in the organic exhalations.

Dr. William Budd insisted on the harmlessness of human excreta unless infected by a previous case of typhoid fever, but Murchison taught the doctrine of pythogenesis or filth origin, irrespective of any previous case, and his doctrine prevailed for many years. Hence the slightest flaw in a system of sewage removal was accepted as an explanation in full of the presence of typhoid fever. The sanitary order of the day thereafter insisted on improved methods of sewage removal, and much good was thereby effected. Cleanliness and dry-earth systems benefited the country, and "plumbing regulations" gave city houses protection against sewer air, notwithstanding their intimate connection with the sewers. These hidden and too often uncared-for conduits were inspected, repaired, flushed, and ventilated until their air became purer than that of many city tenements. At this time no one seemed to observe that the evidence against sewer air as regards typhoid fever consisted only of assumption and assertion. When the sewers and house drains, the soil pipes and the traps were found to be perfect, the typhoid-fever element of sewer air was assumed to be so penetrating that coming up from the sewers it would saturate the water in a trap and be exhaled into a closet from the upper surface of the water; and if the closet was so situated that its air could communicate with that of a living room or a bedroom, a case of typhoid fever was considered satisfactorily accounted for. Ultimately the propagation of the disease by a contaminated water supply and the discovery of the typhoid bacillus made the innocence of sewer air evident in many cases in which it had been tried hastily and condemned unjustly.

Sewer air is, however, always putrefactive and sometimes specifically infective. In the wide streets of a well-ventilated city, the bacteria in its sewer air, when diffused into the atmosphere at large through ventilators, are carried away, dried up, and deprived of their vitality before they have opportunity of doing harm; but as we may have vitiated air from the lungs in an unventilated room, so we may have vitiated air from the sewers in unventilated streets. The air of narrow streets in densely built localities where there is little air movement, as is often the case in summer, may become tainted with the putrefactions and infections of the sewers, and an epidemic constitution of the atmosphere may thus find an actual existence, manifesting itself by an unusual prevalence of diarrhœal or specific diseases.

The air of dwellings is sometimes contaminated with ground or cellar air drawn up through a porous soil by the greater warmth of the living rooms. Ground air contains more carbon dioxide in summer than in winter on account of the influence of heat in promoting decomposition of organic matters in the soil. In general terms it contains in summer more and in winter less than one per cent. of this gas, or one hundred volumes in ten thousand of the air. It may also be contaminated by other products of decomposition, together with forms of bacterial life, for it remains to be proved that such particulate nitrogenous substances are removed by a filtration through the loose pores of the soil in which they are multiplying. Besides, in this question, evaporation from the surface is involved as well as filtration through the substance. The passage of air through and from the soil promotes evaporation from the surface, which may carry with it microscopic forms of life. Hence may be inferred the inadvisability of furnishing cellar air or air introduced by tunnels into a building for purposes of ventilation. This applies in particular to buildings erected on *made* ground. In fact, cellars, in default of an impermeable lining, should have a free circulation of air separate from the ventilation system of the superimposed building.

Charles Smart.

AIR EMBOLISM. See *Embolism*.

AIR PASSAGES, FOREIGN BODIES IN.—NOSE.—The presence of foreign bodies in the nose[1] is of common occurrence. The list[2] of them comprises extraneous substances introduced either through accident or design by infants or insane adults; sequestra of diseased bone; and parasites. They may also enter the nasal cavities from behind, during the act of vomiting or of choking, or in paralysis of the soft palate. Rarely, as in gunshot wound, they may pass through the walls of the nasal cavity from without. The history of those of the first variety is usually as follows: A child of about two, old enough to creep but not sufficiently intelligent to know better, thrusts some small, rounded object, such as a bean or a shoe-button, which it has found upon the floor, into its nostril. If the child be not caught in the act the body may escape immediate detection. Soon symptoms of chronic inflammation are established. These are confined to the nostril in which the body is, and continue until it is removed, the irritation often being severe and the discharge exceedingly fetid. The mucous membrane adjacent to the foreign body is in a condition of superficial erosion. The body, if too firmly impacted to be dislodged by simply blowing the nose, remains fixed, usually in the inferior meatus, until removed by the surgeon. Removal should be attempted by means of a hooked probe or fine forceps, the sensitiveness of the nasal cavity being borne in mind, and the removal of the body carefully accomplished after complete local anæsthesia of the nasal cavity has been obtained, either by

cocaine or by the extract of suprarenal capsule. Copious hemorrhage, lasting two or three minutes, often follows, but is generally of little moment. The nostril should be washed several times a day with a weak disinfectant. In four or five days the membrane will often have healed so completely that no trace of trouble can be seen; the discharge ceases entirely, and the cure is complete. The possibility of the presence of a foreign body in all cases of fetid discharge confined to one nostril should always be remembered, and, the nostril having been cleansed with a warm douche, examination should be made with probe and speculum. If the object be lodged far backward, care should be taken in removing it not to allow it to fall into the larynx. Rhinoliths[3] are merely calculi formed by an accumulation of the earthy salts of the nasal secretions around some foreign body or inspissated mucus. Their presence has given rise to such irritation that they have been mistaken for cancer. Careful examination and the history of the case will easily establish the diagnosis. If the concretion be too large to be readily removed it should first be crushed. Foreign bodies of this nature are rarely met with, although one is reported which weighed seven hundred and twenty grains. Sequestra of bone, particularly in tertiary syphilis, sometimes remain in the nasal cavity after their separation, thus acting as foreign bodies. They must be thoroughly removed preliminary to further local treatment.

Parasites.—In tropical countries, seldom elsewhere, various kinds of flies, of the order *Muscidæ*, may enter the nasal cavity, preferably of a patient suffering from catarrh, and there deposit eggs.[4] These are quickly hatched, causing in succession irritability, tickling, and sneezing; later, formication, bloody discharges, and epistaxis, with œdema of the face, eyelids, and palate; excruciating pain, generally frontal; insomnia, and if the condition be unrelieved, convulsions, coma, and death. Sometimes the larvæ are sneezed out, or may be seen on examination of the parts. This will, of course, establish the diagnosis. Destruction caused by the larvæ may extend to the mucous membrane, the cartilages, and even the bones of the head; the ethmoid, sphenoid, and palate bones having been found carious. Where the maggots have entered the frontal sinus or the antrum of Highmore, injections of tobacco or alum, or insufflations of calomel, formerly used, will be of little use. Chloroform or ether,[5] preferably the former, either inhaled or driven into the nasal recesses in the form of spray, is the sovereign remedy, as under it the larvæ are not killed, to remain *in situ* and thus cause further trouble, but escape with all haste to the outer air. Meanwhile, anodynes should be given to allay pain, and the patient's strength should be carefully sustained.

Such measures, however, are only serviceable when the case is seen early and the larvæ are still upon the surface of the mucous membrane. When they have attained their full development, they burrow into the soft tissues, whence it seems impossible to extract them except by seizing them bodily and dragging them out. If the desperate character of the situation in severe cases of this kind, and the impossibility of reaching the seat of irritation through the natural passages, are taken into consideration, no surgical procedure which promises relief can be thought too severe. It is therefore justifiable to open into the antrum or the frontal sinuses from without, to perform Rouge's operation, in order to gain access to the upper part of the nasal cavities or to open freely into the ethmoid cells. Several cases in which the patient's life has thus been saved have been related to the writer in recent years.

Leeches, ascarides, earwigs, and centipedes[6] have been found in the nose, causing insomnia, frontal pain, sanious discharge from the nose, lachrymation, vomiting, and, in some cases, great cerebral excitement. Sternutatories are generally sufficient for their expulsion.

Tonsils.—Three general varieties of foreign bodies may be found in the tonsil: (1) Foreign bodies proper, or substances which have become lodged in the tonsil during deglutition; (2) tonsillary concretions or calculi; (3) parasites. The last two conditions are not common; the first will be described under Foreign Bodies in the Pharynx.

Tonsillary calculi are formed in the lacunæ of a chronically inflamed tonsil by a perverted condition of the natural secretions, and their retention in the recess through closure of its outlet. They vary in size, seldom attaining a greater diameter than three-fourths of an inch, and consist of phosphate and carbonate of lime, some iron, soda, and potassa, with varying proportions of mucus and water. Hence they are not necessarily of gouty origin.

The *symptoms*, generally not prominent, may be slight pricking of the throat with, occasionally, dysphagia. The presence of the calculus is sometimes directly irritating, and may give rise to quinsy, ulceration of the cavity, and abscess. Frequently, however, the symptoms are reflex in character. This is especially true with relation to the ear, in which organ the existence of a calculus may be associated with various forms of otic congestion and with tinnitus.

Diagnosis, by ocular examination or by the use of the probe, is usually easy, and so also is the removal of the calculus by means of a forceps. Sometimes, however, the mass is so completely covered that it is only seen after careful exploration with the probe or even after the actual removal of the tonsil. In most cases the latter operation will afford the most certain cure. Very rarely, hydatids and trichocephali have been found in the tonsil.

Pharynx.—Foreign bodies are very often arrested in the pharynx, and the variety of these bodies is very great. Certain individuals seem especially liable to this accident, either from carelessness in eating, from insensibility of the parts, or from some unusual irregularity in the pharyngeal walls. Foreign bodies of large size generally lodge in the lower part of the cavity, where the cricoid and arytenoid cartilages project backward, or between the base of the tongue and the epiglottis. Small and sharp-pointed bodies may become fixed at any part of the pharynx, particularly in the tonsils, on account of their exposed position and the irregularity of their surface. They may also be entangled in the pillars of the velum, or in the lateral folds of the cavity. A large body may be found stretching across the whole width of the pharynx.

Symptoms.—These are local pain, dysphagia, and more or less inflammation, with occasionally ulceration or abscess of the pharynx; but generally there is simply localized inflammation and irritation. If an abscess be formed, the foreign body may escape through a fistulous opening in the neck, or it may perforate some important blood-vessel, or may even penetrate the intervertebral substance and cause caries of the vertebral bodies.

Inflammation of the pharynx may give rise to dyspnœa, while a large foreign body may cause suffocation by obstructing the entrance to the larynx.

The *diagnosis* can generally be established by the history of the case, and by inspection of the pharynx. Nervous patients often insist upon the presence of a foreign body in the throat, despite all assurances to the contrary, particularly if the pharynx be sensitive, or if at a certain point there is an inflamed lymph gland, or if, as often happens, a hard substance may have caused a slight laceration of the mucous membrane while being swallowed.

Treatment.—The patient's tongue should be well depressed, and the upper parts of the pharynx carefully examined in a strong light. If the foreign body does not then appear, search should be made for it, with the aid of the laryngoscope, in the region of the base of the tongue, the glosso-epiglottic sinuses, and the upper portion of the larynx. If present, it will generally be found without much difficulty, and should be removed by the finger or by a suitable forceps or probang. If dyspnœa be urgent, immediate surgical interference, of a nature suited to the special features of the case,—either tracheotomy, thyrotomy, or, possibly, some form

of subhyoidean pharyngotomy,— may be required. The sensations of the patient are often unreliable, and the feeling of irritation caused by the presence of the body may continue for a long while after its removal. This is relieved by swallowing small lumps of ice, and later, if necessary, by the application of astringents and, in some cases, by galvanism.

LARYNX.—By reason of the danger to life which attends the lodgment of a foreign body in the larynx, this condition becomes one of the most important in surgery. The variety of objects found is infinite, and may be thus divided: Alimentary matters, introduced during mastication, in the act of laughing or talking, in deglutition, or in inspiration during vomiting; metallic bodies, such as coins, buttons, puff-darts,[7] etc.; teeth, artificial or natural; necrosed bone[8] from neighboring regions, as from the nose in tertiary syphilis; and fragments of the laryngeal cartilages themselves, as thrown off in the late stages of syphilis, tuberculosis, and cancer of the larynx. Foreign bodies in the trachea may pass upward and become impacted in the larynx; and, rarely, they may gain access to the larynx directly from without, by forcible penetration of its walls, as in the case of bullets.[9] Again, the epiglottis may become incarcerated in the larynx,[10] or occlusion may take place from the so-called swallowing of the tongue.[11]

The *symptoms* vary with the size and position of the object. Thus a large body fixed in the rima glottidis may, unless dislodged, cause almost instant death. Again, small bodies lodged in out-of-the-way corners may remain indefinitely, causing nothing more than cough and discomfort. Dyspnœa may occur days after the entrance of a foreign body, from inflammation and tumefaction of the soft parts of the larynx, and danger from the presence of a foreign body may suddenly become imminent from alteration in the position of the body. Great peril sometimes arises from violent spasm of the glottis, due to irritation caused by the foreign body. Mental anxiety and localized pain are prominent symptoms in cases in which the accident does not immediately threaten life, but is followed by inflammation which rapidly becomes active.

A cautious *prognosis* must be given, even after removal of the body, as long as there are any symptoms of local inflammation. The *diagnosis* is established by the history of the case, verified or otherwise by laryngoscopic examination. The greatest difficulties arise with children too young to express themselves, in whom pain in the throat and symptoms resembling croup will often be the only indications obtainable. Here the use of the laryngosope or direct inspection of the larynx as practised by Kirstein will be indispensable.

Treatment.—The offending body should, of course, be at once removed; if possible, through the natural passages and by means of the laryngeal forceps, aided by the laryngoscope, in case the symptoms are not urgent. Removal may be facilitated by placing the patient on his back upon a table, with the head hanging over the edge of the table, in which position the patient breathes more easily, and the law of gravitation becomes directly helpful. If asphyxia threaten, tracheotomy should be done at once, and the foreign body afterward extracted as described above. Bodies which at first are immovable may sometimes be loosened by reducing the local inflammation. In rare cases, when the object has become firmly impacted, thyrotomy may become necessary. A case is recorded in which a needle, transfixed in the larynx, was pushed through the anterior laryngeal wall, and thus removed.[12]

TRACHEA AND BRONCHI.—Any object which can pass through the rima glottidis may, of course, find its way into the trachea, in the same manner as was described in the paragraph relating to foreign bodies in the larynx. Sharp objects lodged in the œsophagus, and even diseased bronchial glands, may work their way through the walls of the trachea, and into its cavity. It sometimes happens, through carelessness or by accident, that parts of instruments used in intralaryngeal operations, tracheal cannulæ,[13] laryngeal brushes, and even bits of solid nitrate of silver, drop into the trachea. If too large to enter either main bronchus, the body will probably remain at the bifurcation. Otherwise it will pass into one bronchus or the other, preferably the right, on account of its anatomical position, in the proportion of five to three, and thence travel indefinitely into one of the more remote bronchial divisions. Asphyxia may also be caused by the entrance of water into the trachea, as in drowning, of blood during a surgical operation, of pus from the bursting of an abscess, of vomited matter, or of liquid food.

The *symptoms* will depend upon the nature of the body and its exact situation in the lung. Small objects have remained encapsulated with mucus for years without causing discomfort or serious results. Smooth, rounded bodies irritate less than irregular ones. Inflammation of the lungs from a foreign body may occur, and at the same time the presence of such a body may be entirely unknown. Large objects and fluids may cause death by instant suffocation, or death may result in the course of a few minutes, the symptoms presented being urgent dyspnœa, and cyanosis from asphyxia. The patient under these circumstances makes frantic efforts to obtain relief. He thrusts his fingers down his throat, he rushes to the window to get fresh air, and he makes strong inspiratory efforts; and if aid be not speedily afforded, death, with all the signs of asphyxia, soon follows. Severe dyspnœa, followed by relief without extrusion of the foreign body, indicates that the body has probably dropped from the larynx into the trachea. Dyspnœa is, of course, more urgent when the trachea is occluded than when the foreign body stops only one bronchus. The body may change its position, passing from one bronchus to that of the opposite side. A body, small when swallowed, may become more dangerous through increase in size, either by imbibition of water or by forming the nucleus of a concretion. Physical signs due to the presence of a foreign body in the lung may be altogether wanting, but they are generally more or less distinct. They are the following: whistling or flapping sounds at the point of lodgment, decreased fremitus, and absence of respiratory murmur in the lung beyond. The diagnosis is often very difficult. At or about the bifurcation the body may be seen with the laryngoscope. The lodgment of a foreign body in the lung may result in pneumonia, tuberculosis, abscess, or gangrene. Or it may become encapsulated and do no apparent harm. Rarely a body, generally an ear of barley or other grain, having formed an abscess of the lung, has been discharged through the wall of the thorax, with complete recovery.[14]

Diagnosis.—The fact that some foreign body has been inhaled should be established if possible, and the site of the body determined. In children and incompetents, and in cases in which the dyspnœa is urgent, this may not be easy. While the laryngoscope may fail to reveal the presence of the foreign body in the trachea, it can at least furnish satisfactory evidence that the object in question is not located in the larynx.

The *prognosis* is serious; it depends upon the nature of the foreign body, the amount of dyspnœa, and the organic lesions which may result. The danger is greatest at the first, and although it diminishes in varying degree as time passes, it is never entirely absent. Even after expulsion of the foreign body death may occur from the organic disease set up. The expulsion of one object does not, especially with children, preclude the possibility of others remaining in the lung.

Treatment.—The treatment of foreign bodies in the trachea must be determined by the circumstances of the case and by the nature of the foreign body. When the trachea and bronchi are filled with fluid the patient should be placed upon his back, the head and shoulders as low as possible, the mouth should be forced open, the tongue drawn far forward, and the walls of the chest compressed. Artificial respiration should be instituted the moment the trachea is sufficiently free to allow of the ingress of air.

The treatment of solid bodies which have gained access to the trachea or bronchi is one of the most difficult things in surgery. In brief, if the object be small in size, regular in contour, and of smooth surface, it appears that better results have been obtained by waiting for spontaneous expulsion than through operation. When the foreign body is rough, irregular, or very large, a low tracheotomy will generally give the best opportunity for its removal. If, as sometimes happens, the foreign body cannot be reached at the time of the operation, the wound in the trachea may be kept widely open in the hope that this body may be extruded on some future occasion.

The conditions demanding speedy operation are: 1. Urgent and dangerous symptoms, as progressive dyspnœa, or frequently occurring attacks of dyspnœa, or laryngeal spasm, when laryngoscopic examination fails to reveal the object or shows that its speedy removal by the natural passages is impossible. 2. When a sharp and irregular body is impacted, as shown by the laryngoscope, in such a way that immediate extraction is impossible, and when acute inflammation, and especially œdema, are rapidly developing, as evinced by increasing dyspnœa. 3. In the case of a foreign body of any nature which lies loosely in the trachea, and the movements of which excite laryngeal spasm or coughing of dangerous violence. 4. In the case of a foreign body which is impacted in either of the primary bronchi, as ascertained by the rational and physical signs, particularly by auscultation. In this latter condition low tracheotomy and immediate direct attempts at extraction are often successful. Direct examination of the site, and demonstration of the foreign body in or at the mouth of a bronchus, by means of the finger introduced quickly into the trachea, are possible, and this knowledge renders the subsequent instrumental removal of the body more easy. The entrance of a foreign body into a bronchus to such a distance as to place it beyond reach through the natural passages, is an accident of the gravest danger. A number of cases have occurred of late years in which surgical operation has been attempted by entering the bronchus through the chest wall from without. All have proved fatal. 5. Sharp-pointed, hard, and irregular bodies within the air passages will, as a rule, demand bronchotomy, provided they are not so located that they may be reached and removed by the natural passages at an early moment. The plan of treatment by inversion of the patient has of late years fallen into disrepute, and should seldom be practised, unless tracheotomy can be done at once if required. In employing it, it should be remembered that the supine position will favor exit of the body, particularly if the glottis be in the condition of deep inspiration. In all cases the diagnostic importance of a thorough laryngoscopic examination cannot be too strongly insisted upon, nor the great utility of the laryngoscope be overestimated.

D. Bryson Delavan.

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AIX-LES-BAINS.—This is a town of about 5,000 inhabitants, picturesquely situated in a beautiful valley on the east shore of the Lake of Bourget, and surrounded by high mountains (the Savoy Alps). It is about twenty hours from London via Paris and Macon, eight hours from Turin, four from Lyons, and three from Geneva. Its elevation above the sea level is 850 feet, and 100 feet above Lake Bourget.

The climate is soft and mild, the average temperature being 55° F. during the year, and the mean summer temperature 70° F. June and September are delightful months. "Owing to its excellent atmosphere," says Linn, "people rest well here."

The thermal sulphurous waters, known to the Romans, for which about 35,000 people visit the town annually, are derived from two copious springs which have a temperature of from 107° to 112° F., and which are called "St. Paul's" and the "Alum." They yield about one million gallons of water daily. They are nearly devoid of solid constituents and contain sufficient sulphureted hydrogen to give them the characteristic odor. "The waters of the two springs are chiefly used for baths, but the 'Alum,' spring is likewise used for drinking. For internal use, however, the stronger cold water of Challes, near Chambéry, and of Marlioz are chiefly employed.

"The waters and the various methods of treatment employed at Aix are of service in cases in which indifferent thermal waters are of use"; the methods of treatment are probably the most efficacious in producing the results. "The diseases which receive especial benefit from the Aix treatment are chronic gouty and rheumatic affections, muscular rheumatism, sciatica, neuralgia, neurasthenic conditions in arthritic subjects, chronic cutaneous eruptions, and chronic catarrhal affections of the mucous membranes." "In rheumatic arthritis," says A. B. Garrod, "the value of the Aix course far exceeds, according to my experience, that of any other known spa." Excellent results are also obtained in the stiffness of joints arising from former injuries and from gouty and rheumatic affections.

The large bathing establishment is the property of the state, and is one of the most efficient of these institutions known. There are swimming baths (*piscines*), fifty douche rooms with conveniences for administering massage; six vapor rooms (*bouillons*); five hot dry-air rooms (*étuves*); two general vapor baths (*caisses*); and four apparatuses (Berthollet's) for applying vapor locally.

There is a special *piscina* for the treatment of chronic skin affections by prolonged baths, after the method of Loëche-les-Bains. Poor people are cared for as well as the rich. The especial feature at Aix, for which it is so famous, is the "douche massage," consisting of the methodical application, by two skilled attendants, of massage combined with douches. This procedure, which may be used for the whole body or especially applied to the desired part, is to be carried out in the following manner: The patient is seated upon a wooden stool, and two attendants, male or female as the case may be, pour the water upon the body from a hose, while at the same time they shampoo, knead, and rub according to the directions given by the physician, who accompanies the patient to the douche the first time, to give instructions as to temperature, force, duration, and pressure on particular parts. The masseurs have each a hose under their arms from which they direct the water over the bather. The "douche massage" may be combined with passive movements of special joints, to be followed

or preceded by a vapor bath in the adjoining *bouillon*. In many cases patients, after walking to the bathing establishment, send back to their hotel their clothes, and, at the close of the bath (which lasts about ten or fifteen minutes), they are rubbed dry, wrapped in a blanket, and carried in bath chairs by porters back to their hotel and put to bed (see Fig. 68). "The men and women who perform the douche massage have had their art handed down to them for many years, as their fathers and mothers were masseurs and masseuses before them." The Aix waters have an unctuous quality which makes them particularly adapted to rubbing and kneading the muscular structures, a quality that is not found in other waters. While using the waters the patient's diet is carefully regulated by the physician.

Some two thousand douches and one thousand baths are often given daily during the season.

The sanitation of Aix is excellent and the accommodations are ample and satisfactory. The season extends from April to November, though the baths are open the entire year. July and August are the most frequented months. In this country the Hot Springs of Virginia, and the springs of Richfield and Sharon in New York State, correspond to the waters of Aix as to the class of diseases treated, and the bathing establishments at these places are modelled after those of the European spas.

For much of the above description of Aix-les-Bains the writer is indebted to Weber's "Spas and Mineral Waters of Europe," 1896; to Linn's "Health Resorts of Europe"; and to the articles in the previous edition of the HANDBOOK. *Edward O. Otis.*

AJACCIO.—The principal town of the island of Corsica, with a population of 20,000. It is situated in the centre of a beautiful and well-protected bay opening to the southwest. "Fifteen to twenty miles in the rear of Ajaccio is a semicircular mountain chain of granitic formation sloping down to undulating foothills, and presenting a glowing panorama at sundown. During the winter season the distant peaks of Monte Cinto, Rotondo, and d'Oro are capped with snow, and the chilly northeast wind over the gulf of Genoa is dried and broken in force before it reaches the western shore, where it is again arrested near Ajaccio by the sheltering hills surrounding the town" (A. Tucker Wise: Transactions of the American Climatological Association, 1890). The visitors' quarter is along the Course Grandival in the northwestern portion of the town, "which is the section most protected and best sheltered from the winds." "The soil at Ajaccio is disintegrated granite, and allows a rapid disappearance of the heavy showers which fall during the autumn. But, unlike the Riviera, this locality has only a small rainfall in March."

FIG. 68.—Method of Conveying Patients to and from the Thermal Establishment at Aix-les-Bains. (The patients are wrapped in blankets only.)

The water supply is of a pure quality, and is brought to the town from Carazzi, twelve miles distant. "The drainage of Ajaccio is certainly not perfect," says Wise, "but zymotic diseases are very uncommon." "The town itself," continues the same authority, "is one of the dirtiest, and its only title now (1890) to the fame of a health resort lies in the climate solely." "Invalids, however," he sententiously adds, "cannot live on climate alone."

The vegetation is most luxuriant, and all the principal streets are bordered with avenues of acacia, orange, or citron trees. Bananas, oranges, lemons, a variety of cacti, the castor oil plant, prickly pear, aloe, fig, and olive flourish.

"I, at any rate," writes D. W. Freshfield in the *Alpine Club Journal*, quoted by Ball, "know of no such combination of sea and mountains, of the sylvan beauty of the North with the rich colors of the South; no region where within so small a space Nature takes so many sublime and exquisite aspects as she does in Corsica. Orange groves, olives, vines and chestnuts, the most picturesque beach forests, the noblest pine woods in Europe, granite peaks, snows, and frozen lakes—all these are brought into the compass of a day's journey."

The accommodations now appear to be ample and satisfactory, both from the standpoint of health and from

that of convenience, whether one desires hotel, pension, or villa.

As to the meteorology of Ajaccio, the mean temperature during the winter is about 55° F. with a small daily variation of not more than 10° F.; this is two or three degrees higher than the mean temperature of the Riviera.

"During the season (November to April) the thermometer rarely rises above 59°, or falls below 50°" (Ball). The relative humidity is given by Wise as 80 per cent., and by another authority as varying between 70 and 78 per cent. The average number of rainy days for the season is stated by Wise to be 30, and by the writer on Ajaccio in Eulenburg's "Real-Encyclopädie," for the months from October to April inclusive, 40 to 45. During the three rainy months, December, January, and February, the average number is not more than 14, according to Ball. The prevailing wind is the southwest, which is "a temperate and soft wind, with genial bright weather, and prevails as a high current throughout the greater part of the winter, and in spring its continuance for a prolonged period is almost a certainty" (Wise). The southeast wind ("sirocco") is a very depressing one, producing loss of appetite and sleeplessness. "From my own personal point of view," says Wise, "I regard Ajaccio as the most comfortable climate I have ever visited, with the exception of the winters in the Bermudas, and, in comparison with Madeira, it is certainly more bracing and agreeable to the able-bodied." The climate can be characterized as a moderately moist, mild, marine climate, with a comparatively large number of sunny days, ranking between Madeira and the Italian Riviera, but warmer and more equable than the latter. On account of the hard granite soil there is no dust, and winds are infrequent.

"It has always been a matter of surprise to me," says Williams ("Aero-Therapeutics," 1894), "that Ajaccio has not been more utilized as an alternative climate by the Riviera medical men, when their own has proved too stimulating or too marked by radiation extremes, for this mild, moist atmosphere, with its freedom from all but sea breezes, and its good hotels and quiet surroundings, seems to supply the requisite and beneficial change."

The phthisical patients for whom this climate is especially well adapted are those who can afford but little physical effort in order to exist—cases of "phthisis of advanced life, with cardiac feebleness, where the powers of resistance to cold are at a low ebb, or there is much emphysema with cold, livid extremities" (Wise). It is also beneficial for those in whom "the breathing powers are greatly diminished or when a stubborn cough is a prominent symptom." Certain cases of incipient phthisis which are unsuited to the altitude treatment do well in Ajaccio; and the same remark applies to those affected with nervous irritability who require a soothing climate.

Ajaccio is reached by steamer from Nice and from Marseilles in twelve and a half and eighteen hours, respectively.

Edward O. Otis.

AJOWAN.—(*Ajava; Bishop's Weed.*) The fruit of *Ptychotis Coptica*, D. C. (fam. *Umbelliferæ*).

This plant is supposed to be indigenous to India, where it has always supplied an important cultivated crop. The fruit—one of the cremocarps commonly called "seeds"—is prized for table use, as well as for its medicinal properties. It is employed in all cases requiring a carminative, and its action is powerful. It has also been much used in cholera, combined with camphor, on account of its powerful stimulation of the abdominal nerves, and for its antiseptic effect. These uses are fully explained when it is known that the plant contains four per cent. of a volatile oil rich in *thymol*, and that it is largely used as a source of that substance. Its properties and uses are therefore those of that drug. The dose is 1 to 2 gm. (gr. xv.–xxx.).

H. H. Rusby.

AKINESIA. See *Paralysis*.

AKINESIA ALGERA.—(ἀ-κίνησις, without motion; ἄλγος, pain.) Moebius[1] has given this name to an array of symptoms, among which the most characteristic is loss of power of movement as the result of accompanying pain, while no sufficient cause for the latter symptom has yet been found.

The cases which he reports were persons of neurotic inheritance, so-called *déséquilibrés*, in whom the disease manifested itself after mental overexertion. In the one case neurasthenia, in the other hysteria, was present. In both cases the disease was quite protracted. The first case reported by him occurred in a man, a teacher in the gymnasium, thirty-three years old. The father suffered from paranoia. The patient during his youth was very excitable and extremely ambitious. There was no history of sexual perversion. In 1887 he suffered from headache and insomnia. In the spring of 1888 he was unable to carry on his work, and was sent to an institute. Subsequently to this there occurred a loss of memory for three or four weeks. After every movement the patient experienced a heaviness of the limbs and pains in the muscles. Improvement took place under prolonged rest, or the Weir Mitchell treatment. Following this a relapse occurred, during which the patient abstained from all movement of the limbs. The skin and tendon reflexes were present, the patellar reflex was quite marked. On the right side the ankle reflex was weak; on the left it was marked. There was found hyperæsthesia in the hands and forearms; no points of pain, however, were discovered. Organs of special sense were normal. Every voluntary movement of the limbs and trunk was accompanied by severe pain, lasting for hours. These pains were most marked in the forearms. The head was free from pain, and there was no difficulty in moving it. There was a very slight muscular atrophy of the left hand, which was possibly caused by the pressure of pasteboard splints.

In the way of treatment, bromide of potassium, given in the evening in doses of from three to four grains, produced rest. Hypnotic suggestion was without result. Improvement followed after several months' rest. The tendon reflexes became weaker and finally normal, there remaining a weak ankle clonus on the left side. Subsequently to this, and following a considerable excitement, a relapse occurred, with subsequent improvement. The hands, however, remained quite painful.

The second case occurred in a woman, forty-three years of age, by occupation a teacher of music. A neurotic family history was given. From her twentieth year onward the patient had suffered from tremors, with semi-unconsciousness. The hands were painful, and were held in a flexed position. She also suffered from insomnia, and was incapable of mental work. The feet were painful, and walking was impossible. After suffering in this way for ten years improvement set in, and the patient was comparatively well for a subsequent period of ten years. In the summer of 1889, probably as the result of overwork and excitement, a relapse occurred, from which she had not recovered up to the time of the report. There were found extreme irritability, a forced position of the hands, and pain in the legs. The latter could be moved, but they soon became tired, and suffered from quite severe after-pains. Auditory and visual functions were normal. Hypnotic treatment was without result. The patient twice attempted suicide, and finally gave evidence of mental trouble, with hallucinations of persecution. She subsequently died in an insane asylum.

In a subsequent publication[2] Moebius reports another case in which, in addition to the absence of motion resulting from pain, and really superseding it in importance, there was present an extreme degree of photophobia. We have here a condition very similar to that which has occurred in regard to motion, a condition in which the patient will not see because of the attending pain.

Moebius seeks to widen the term by calling it "apraxia algera," or abeyance of the function of any or all organs because of the pain attending their functional activity.

In the last case this was very well illustrated by the very severe pain in the head attending any mental effort whatever. The case has a further interest in that the report is taken from the "Autonosography" of the distinguished psycho-physicist, Gustav Theodor Fechner.

Longard[3] reports a case that occurred in a young lady, aged twenty-nine. Her mother had suffered from arthritis deformans; her father, in 1874, became afflicted with paranoia. The patient had for years previously suffered from pelvic troubles (pelvic inflammation, uterine fibroids, metritis, etc.). The symptoms observed in this case were mental excitement and peculiar pains over the entire body, which later became so severe as to compel the patient to abstain from all motion. The psychical excitement also increased. During the later period of observation, retention of urine, marked constipation, and very obstinate insomnia showed themselves. Objectively, an increase of the tendon reflexes was found. The course of the disease was not materially altered during six months' treatment in the hospital. Improvement occurred later as the result of improved surroundings.

Longard calls attention to the fact that these cases of akinesia algera give the same clinical picture as was formerly described under the name of spinal irritation.

According to Moebius the affection is a functional or psychic one, and is not due to organic disease. The pains he regards as hysterical, or pain hallucinations. The disease itself is not, however, a pure hysteria, but may be regarded as an analogue of the general anæsthesia described by Krukenberg, Heyne, and von Ziemssen. The cases reported by W. Neftell in 1883, and called by that author atremia, are regarded by Moebius as similar to his cases.

The prognosis is not very favorable. In the matter of treatment the best thing to do is to accede to the wishes of the patient for rest. *S. P. Kramer.*

[1] Deut. Zeit. für Nervenheilkunde, 1891, vol. i.
[2] Ibid., vol. ii., 431.
[3] Ibid., vol. ii., 455.

ALASSIO.—A winter health resort on the Italian Riviera, which is lately claiming an increased share of attention. It is prettily situated, but owing to its comparative newness the accommodations for invalids are far from perfect. The only reliable meteorological data available are those of Dr. Schneer ("Alassio and Its Climate," Turin, 1878) and a synopsis published by Dr. M. G. Foster (*British Medical Journal*, November 7, 1891). Dr. Foster, who is now practising at San Remo, informed the writer that the authorities of Alassio appeared to lack energy in effecting reforms, more particularly from a sanitary point of view. Dr. Foster spent two winters at Alassio, and did not observe any typhoid fever there; but it is said to occur there every summer. There is no system of drainage, the excreta being collected in cesspools. The drinking water is hard, but as to organic impurities reliable data are not at hand to justify its condemnation or acceptance. Sparks ("The Riviera," London, 1879) claims that the water is good and potable.

Alassio is on the north shore of the Mediterranean, about equidistant from Nice and Genoa. It lies at the head of a curving bay, which is some five miles wide. The town has about 6,500 inhabitants. Its latitude is about the same as that of San Remo. Dr. Foster's description is here reproduced, as it is accurate and devoid of local bias:

"Without the gates of the city proper at either end stretches a suburb composed of dwellings of the Italian population mingled with a few villas. Each of these suburbs contains a hotel situated facing the sea, while a third is placed about a hundred yards behind the main street of the town. The villas of the English residents are dotted over the lowermost spurs of the encircling hills. The hills form an unbroken semicircle round the town. Their greatest elevation is on the north (1,963 feet). Numerous valleys run up among the lower spurs of these hills, but none pierce them.

"Alassio thus secures good protection from the north, west, and southwest. The seashore is generally windy, but in the valleys running up among the hills the wind is rarely severely felt, and on most days the air in these situations is almost entirely still."

The records of temperature (as given by Foster) are as follows:

"October has	a mean	temperature of	61.9° F.
November	"	"	54.3° "
December	"	"	49.7° "
January	"	"	47.3° "
February	"	"	48.2° "
March	"	"	52.3° "
April	"	"	56.4° "
May	"	"	64.3° "

"The mean temperature of the three winter months is therefore 48.4° F."

If we turn now to the rainfall observations, we find that the records give the following results:

"October shows an average of 7 days on which rain fell, an average rainfall of 93.1 mm., and a mean relative humidity of 55.2.

"November shows an average of 8.6 days on which rain fell, an average rainfall of 163.7 mm., and a mean relative humidity of 58.

"December shows an average of 5.6 days on which rain fell, an average rainfall of 43.3 mm., and a mean relative humidity of 55.4.

"January shows an average of 4.3 days on which rain fell, an average rainfall of 60 mm., and a mean relative humidity of 52.9.

"February shows an average number of 4.8 days on which rain fell, an average rainfall of 70.9 mm., and a mean relative humidity of 55.7.

"March shows an average of 6.6 days on which rain fell, an average rainfall of 50.7 mm., and a mean relative humidity of 57.9.

"April shows an average of 10.8 days on which rain fell, an average rainfall of 111.9 mm., and a mean relative humidity of 62.8.

"May shows an average of 5 days on which rain fell, an average rainfall of 46.4 mm., and a mean relative humidity of 63.1.

"Fog has been recorded on 14 days in the six winters."

In his summary of what class of cases are likely to derive benefit from a winter residence at Alassio, Dr. Foster expresses the following opinions:

"The climate of Alassio possesses those advantages which a tolerably high and fairly equable temperature, abundance of sunshine, and freedom from fog can give. Cases of gout and chronic rheumatism do well there. Cases of heart disease certainly appear to do well; they eat and sleep better, and, with ordinary precautions, attacks of secondary bronchitis can be prevented. Cases of bronchitis and emphysema, with care, keep very free from winter cough. Cases of phthisis require very careful selection. Early cases, with limited consolidation and only slight fever, generally do well. Later cases with cavities seem to show improvement, the cough and expectoration diminish, and, since the patients can generally pass a fair amount of time in the open air, the appetite and sleep are both improved. Cases characterized by frequent hemorrhage, with only slight physical signs, seem generally to do well. Owing to the proximity of the principal hotels to the sea, the effect of the climate varies in different cases; some patients sleep badly by the sea, and thus lose much of the benefits; others, again, sleep better there than elsewhere. Weakly and strumous children certainly show great improvement, as they can pass a large amount of time on the seashore. Finally, with regard to that numerous class of cases which are sent to the Riviera under the generic title of nervous breakdown, some cases seem to show great improvement

and regain their lost health, while in other cases all the symptoms appear to become aggravated."

Alassio is a somewhat cheaper place to live in than many of the other Riviera stations.

Edmund C. Wendt.

[In a private letter from an intelligent gentleman who resided at Alassio for some months, I quote the following:

"The climate in December and January is somewhat severe indoors in the Italian houses, but one can be perfectly warm and comfortable in the hotels on the sea-beach, and in those villas which have been rebuilt or remodelled by the English. But the climate out of doors is delightful even in these two months, when it does not rain, that is, for more than half the time. Early in February acres of violets for the Paris and even the St. Petersburg market perfume the open air, where they grow quite unprotected, and we had an endless supply of open-air roses all through the winter."

The reader is also referred to "Alassio and its Flora" by Dr. Vincenzo Nam, of Alassio. *E. O. O.*]

ALBINISM. — (Synonyms: Albinismus, congenital achroma, leucasmus, leucoderma, leucopathia, leucism, leucosis, leucynosis, kakerlakism; French, *Albinisme, Albinie;* German, *Leucäthiopie, Leukopathie, Albinismus.*)

The term albinism (Latin, *albus*, white), or congenital leucopathia (Greek, λευκός, white, and πάθος, affection), is used to designate the peculiar condition characterized by congenital absence of pigment in the skin, hair, choroid, and iris, and which is classed under the atrophies. Although albinism has been noted from the earliest historical period, the Portuguese are the first on record to have named this *lusus naturæ*, which they met now and then among the negroes on the western coast of Africa. These abnormal individuals they called albinoes. In some of the African courts, especially in Congo, they are venerated and are known as "dondos." The term Leucæthiopes, *i.e.*, white negroes, has also been applied to them.

The etiology of this condition is absolutely unknown. There have been numerous theories concerning it, many of which have been thoroughly unscientific. The two which seem most worthy of attention are, viz., those of heredity and arrested development. Heredity, as the chief etiological factor in albinism, has been as vigorously upheld as it has been sharply attacked. There are instances on record of families of albinoes. These are very rare, however, and have been said to be observed only in the tropics. It is well known that the offspring of an albino and a black is generally the pure type—either universal albino or black; though some cases of partial albinoes have been reported. However, the children of a normally pigmented individual and an albino are usually not lacking in pigment. Also healthy, normal parents have had albino offspring. In several instances families have been observed in which universally pigmented children have alternated in birth with albinoes.

The second theory, arrested development of the pigment layers, would seem a logical explanation of this physiological abnormality. Kneeland states that "there is a time in the growth of the embryo when there is no pigment, and albinism would seem an arrest of development in this direction just at this point, the other characteristics going on to development, indicating that color is rather an accidental than essential characteristic of races. Other facts pointing to an arrest of development are the uncommonly downy skin and the persistence of the fœtal pupillary membrane in albinoes beyond the ordinary time of their disappearance." According to Jeaffreson, "pigment first makes its appearance in the structures of the fœtus about the sixth or seventh week of conception, where it is found in membranes which later form the choroid coat of the eye. Later it is deposited in the rete, but not fully developed here till after the sixth month." There is still much to be learned as to the embryology of pigment.

Albinism has been ascribed to certain disturbances of the nervous system.

The affection has been said to be endemic in some tropical countries.

Maternal impression has also been suggested as the cause.

Some investigators have attempted to attribute to albinism a pathological origin. Indeed, in early times, albinoes were considered a sort of leper, and consequently were avoided and shunned in life, while after death the bodies were thrown on a dunghill unburied. On account of their faulty vision by day, and their custom of appearing most frequently at twilight, since their sight is most perfect at this time, they were contemptuously called "cockroaches."

Consanguinity in marriage might be considered an etiological factor, an example being noted by Darwin, in which "two brothers married two sisters, their first cousins, none of the four nor any relation being an albino; but the seven children produced from this double marriage were all perfect albinoes."

A theory has been advanced connecting inactivity of the suprarenal bodies with deficiency in pigment and so with albinism.

Also excessive function of the carbon-eliminating organs has been suggested as a causative factor, as well as constitutional insufficiency of iron.

However, all theories concerning the etiology of albinism are so feebly supported that we are forced to conclude with Gould that "the failure of the epiblast to secrete the usual pigment cells is a mystery of molecular physiology that the future must solve."

As to the sex in which albinism most frequently occurs, both male and female seem to be equally represented, different authors inclining toward one or the other according to their individual observations.

Albinoes have been known in all climates and among all races.

Albinism may be universal or partial. In universal albinism the appearance of the individual is very striking. The skin is absolutely lacking in pigment, unless there be sometimes a slight reddish tinge from the circulating blood underneath the translucent surface, the characteristic complexion having a dull waxen pallor. The skin is often roughened, scaly, or scurfy, a condition which is easily explained by its extreme delicacy of structure and the consequent effects of its exposure. It is often covered with a soft white down, though sometimes it is perfectly smooth.

The whole hairy system is colorless. This may be due to the absence of iron in its composition, as in the chemical analyses of hair of various colors, made by the French chemist Vauquelin, black hair has been proved to contain iron, while white hair lacks this element. The texture is peculiarly fine, glossy, and silky. Although the hair is colorless, its appearance is not that of hair whitened by age, but rather that of flax or corn silk. There is one case on record of an albino having red hair (Folker). In the albino of the black race, the hair, though white, is as woolly and the features as characteristic as those of their black brothers.

Although the appearance of the eye in this condition differs so widely from the normal, "the pathological significance of albinism lies solely in the fact that the iris or diaphragm of the ocular camera is transparent, or so nearly so that it does not act as a true photographic or physiological diaphragm" (Gould). This deficiency of ocular pigment brings in its train much pain and discomfort. The usual coloring matter of the eye being absent, the pupil looks bright red from the rich background of blood-vessels, and the iris light pink or a very delicate blue, the variations in tint depending upon the angle of observation and the nature of the illumination. Photophobia is present in the highest degree, the characteristic position of the albino in daylight showing him with one arm held up as a shield for the eyes. There is perpetual nictitation—rapid and repeated motion of the transparent eyelids, which open and shut continually in

the double effort to see, and at the same time to exclude the overpowering amount of light which has free access to the inner parts of the eye. The iris is constantly expanding and contracting. Nystagmus, or oscillation of the eyeballs, which is present, is due to the effort to obtain a clearer view of the objects of vision. Amblyopia is a serious feature in albinism, various causes cooperating to produce it—viz., ametropia, which increases with the age of the albino, and which is due to pressure on the eyeball in the effort to exclude light, retinal exhaustion, and nystagmus. Myopia is also common.

It has been generally supposed that albinoes are weak both in body and in mind, but this has been proved to be a mistake. Often the albino member of a family has been intellectually the strongest, many of these unfortunates being particularly shrewd.

Partial albinism is observed as one or more patches, colorless or pinkish, generally circumscribed and irregular, of any size or form. Instances have been noted, however, in which these patches were symmetrically disposed, corresponding to the course of peripheral nerves, as similarly happens in the case of certain pigmentary and verrucose nævi. They may be in any part of the body, being most common, however, on the scalp, face, dorsal surface of the hands, nipples, and genital region. The hair on these spots is generally white. The eyes are usually normal, showing the ordinary amount of pigment, though they may be bluish or pinkish. Negroes having this affection are called pied or piebald. The hair is flaxen or red. These patches generally remain permanent through life, or they may gradually extend till they include a large surface; they have been known to change to a normal appearance through a redeposition of pigment, although this is rare.

Albinism has been noted not only in man, but also in the lower animals, and among plants, a very common example among animals being the pink-eyed white rabbit. It is seen in elephants, otters, horses, cows, hogs, dogs, cats, squirrels, rats, mice, raccoons, ferrets, hooting owls, leather-wing bats, doves, ducks, chickens, pigeons, parrots, blackbirds, robins, martins, swallows, sparrows, and the silver variety of goldfish.

It has been suggested that the etiolation of plants kept in the dark may belong in the same category, but this differs from persistent lack of pigment, since color returns on exposure to light.

As to the therapeutics of albinism, there is absolutely no remedy for the affection.

Emma E. Walker.

ALBURGH SPRINGS.—Grand Isle County, Vermont.

POST-OFFICE.—Alburgh Springs.

ACCESS.—Via Vermont Central Railroad to Alburgh Springs Station; thence one mile to Springs hotels.

We have been unable to obtain recent information of this old-time New England resort, which has been in use since the year 1816. The springs are located on the shores of Missisquoi Bay, and are surrounded by picturesque lake and mountain scenery. The situation is 30 feet above the level of Lake Champlain and about 80 rods from the water's edge. There are two springs, one of which was analyzed by Dr. C. T. Jackson, in 1868, with the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium sulphate	7.11
Potassium sulphate with potassium sulphide	9.50
Sodium chloride	8.76
Magnesium chloride	5.02
Calcium chloride with calcium sulphate	4.81
Insoluble matter	0.80
Organic matter, acid, and loss	2.00
Total	38.00

The water gives off a large quantity of sulphureted hydrogen, and may be placed in the saline sulphureted class of mineral waters. We are informed that an analysis by Professor Chandler, of New York, shows also the bicarbonates of lithium and strontium. The other spring in the neighborhood is of a ferruginous character.

James K. Crook.

ALCAPTONURIA. See *Diabetes Mellitus.*

ALCOHOL.—A. ETHYLIC ALCOHOL.—*Ethyl hydrate; Spiritus Vini.* The term alcohol, once used to signify ethyl hydrate, is now generally applied, as a generic term, to a series of organic compounds having in common certain chemical characteristics, the representative of which class is ordinary alcohol. It is produced by (1) the fermentation of all saccharine bodies; (2) synthesis in the laboratory. In composition it is a hydrate, *i.e.*, the combination of a basilous radical with HO, and possesses the chemical properties of other hydrates, in forming salts with acids, etc.

PREPARATION.—Alcohol is produced by a particular ferment (*Torula cerevisiæ*) acting upon saccharine substances, causing them to split up into alcohol and carbon dioxide, *e.g.*:

$$\underset{\text{Glucose}}{C_6H_{12}O_6} = \underset{\text{Alcohol}}{2C_2H_5HO} + \underset{\text{Carbon dioxide.}}{2CO_2.}$$

This fermentation is called the vinous fermentation. We may start with a substance already containing sugar, or we may start with one containing starch, and, first converting the latter into sugar, add the fermentative process. The resulting liquid, containing the alcohol, contains also carbonic acid gas, and is known as a fermented liquor. It may be used in this, the carbonated or "sparkling" condition, all the effects of the alcohol exhibiting themselves, or it may be left until the CO_2 has escaped; or the alcohol may be distilled off in a more or less impure condition, giving us a distilled alcoholic liquor or spirit.

Cane-sugar and milk-sugar undergo a conversion first into glucose and then into alcohol. Minute quantities of acetic and succinic acids, also traces of aldehyde, fusel oil (amyl alcohol), and glycerin are produced at the same time. It is an interesting and important fact that the fermentation gradually ceases as the alcohol produced nears eighteen per cent. strength, and when the latter is reached further action ceases. This is due to the action, on the ferment, of the alcohol itself; the strength named above being just able to precipitate it. In the grape juice, when this strength is reached, if there still be unfermented sugar, a "sweet" wine results; if none, a "dry" wine.

When any of the fermented liquors are distilled, alcohol mixed with water passes over into the receiver. Repeated distillations free it from the greater portion of higher alcohols and water. Its degree of concentration can then be determined by taking its specific gravity and comparing the result with a fixed and official table in which the strength for each specific gravity is worked out. The last amounts of water can be gotten rid of only with the greatest difficulty; as, for example, by distillation over quicklime out of contact with air (from which it rapidly abstracts moisture).

In a diluted condition, under the influence of another ferment, alcohol is changed to acetic acid by a process of oxidation; thus, *e.g.*, white wine vinegar is produced.

$$\underset{\text{Alcohol}}{C_2H_5HO} + O_2 = \underset{\text{Acetic acid}}{C_2H_4O_2} + \underset{\text{Water.}}{H_2O.}$$

Alcohol occurs in commerce and pharmacy in varying degrees of concentration. When absolute alcohol is required, it should be freshly prepared, that of the shops being often only of 98 per cent. strength. Absolutely pure alcohol is a colorless, limpid, pleasantly smelling liquid having a sharp, burning taste; boiling at 78.5° C. (173.3° F.), and, at 20° C., having a specific gravity of 0.7895. Its affinity for water is intense, even abstracting it from the air when the bottle is not securely corked. If it be mixed directly with water, heat will be produced, the volume of the mixture being less than the sum of the

volumes of the components, thus showing that combination has resulted. It is a solvent of great power, advantage of which is taken both in the arts and in medicine, *e.g.*, in the solutions of the *fixed* active principles of drugs, called tinctures, or the solutions of the *volatile* active principles, called spirits. It dissolves the alkaloids, essential oils, many resins, some fats, and CO_2 freely.

Its distinguishing chemical properties are: (1) its affinity for water; (2) its coagulating power on albuminoids; and (3) its antifermentative power when stronger than eighteen per cent. Advantage is taken of the first, in the mounting of microscopical sections, to abstract all the water before immersing them in the oils and balsams; of the second, in the hardening of the tissues for study and section; of the last, in the preservation in bulk of anatomical specimens, and those medicinal agents which undergo change in other media.

Alcohol, U. S. P., is defined as "a liquid composed of about 91 per cent. by weight, or 94 per cent. by volume, of ethyl alcohol, and about 9 per cent., by weight, of water." It has a specific gravity of 0.820 at 60° F. and boils at 78° C. (172.4° F.).

Alcohol Absolutum, U. S. P., is "ethyl alcohol, containing not more than 1 per cent., by weight, of water." Its specific gravity and boiling point are stated above.

Alcohol Dilutum, U. S. P., is "a liquid composed of about 41 per cent. by weight, or about 48.6 per cent. by volume, of absolute ethyl alcohol, and about 59 per cent., by weight, of water." It has a specific gravity of 0.938 at 60° F.

Alcohol Deodoratum, U. S. P., is "a liquid composed of about 92.5 per cent. by weight, or 95.1 per cent. by volume, of ethyl alcohol, and about 7.5 per cent., by weight, of water." It has a specific gravity of 0.816 at 60° F.

Physiological Action.—The extraneous effects of alcohol are of high importance. By the creation of a partial vacuum upon the cooling of an enclosed space previously heated by burning it, glasses are affixed in cupping. It is a powerful disinfectant, especially antizymotic, being thus one of the best and most generally used preservatives.

Its local effects are even more important. Externally, it is cooling by its evaporation, although, if the solution have a strength of fifty per cent. or more, it becomes a rubefacient, especially if rubbed into the surface, or if its vapor be confined. It is slightly locally anæsthetic, especially in relieving itching, and, through the contraction of the vessels by its cooling effect, may locally check perspiration. Its solvent, combined with its disinfectant and stimulant properties, render it a useful lotion for cleansing diseased surfaces. If, however, the solution be strong, it acts rather as an irritant, and, by the abstraction of water, and the partial and temporary coagulation of the albumen, as an astringent. It acts very promptly upon mucous surfaces, being, as upon denuded tissues, stimulant to irritant and more or less astringent. Its presence in the mouth stimulates the secretions, not only of the mouth, but of the stomach. Even a few drops applied at the base of the tongue have been seen to produce an almost immediate flow of gastric juice. The intellectual functions are thus reflexly stimulated also, though later, by direct contact with the cells, the opposite effect is produced, both upon the salivary glands and the brain. If held in the mouth, it produces a numbing effect.

Small quantities of alcohol, properly diluted, taken into the stomach, produce an agreeable sensation of warmth. A turgescence of the capillary plexus of the mucous membrane occurs, which is speedily followed by a free secretion from the gastric follicles, due, in all probability, to (a) the increased supply of blood, and (β) the stimulation of their glandular orifices. The movements of the stomach, as well as its secretions, are increased, and absorption of the products of digestion is greatly hastened. It is therefore one of our most powerful stomachics and digestive stimulants. These effects are not lost upon the absorption of the alcohol, but appear, upon the contrary, to be still further increased by its presence in the circulation. Its presence, however, in any considerable quantity in the food mass inhibits proteolysis, while in concentrated form it acts rather as an irritant, and its favorable action upon digestion is wanting. The direct irritation may result even in vomiting. Continued concentrated doses tend to produce chronic gastritis and gastric catarrh. Moreover, the continued recourse to this artificial aid to digestion tends to necessitate it; and in increasing degree. Larger and larger amounts are required, and the natural powers of digestion become permanently and seriously impaired, and at length are almost completely lost. Aside from the effects upon digestion already described, the action of alcohol in the stomach is one of reflex stimulation of the heart and of the respiration, provided that the drug is not too much diluted. In the intestine, peristalsis is directly stimulated, and an astrigent effect produced.

Alcohol is very promptly absorbed, and circulates as alcohol, in which form it comes into contact with the tissues and exerts its peculiar activities.

The liver, being the first to receive the blood freshly charged with alcohol, in a more concentrated condition than after dilution by the general circulation, is the first to feel its stimulating effect, and the first to undergo pathological changes. The liver cells are stimulated, and as a result we have an increased flow of bile. Later, the cells enlarge and become infiltrated with fat globules. The stronger drinks, particularly if taken undiluted, and if the practice be persisted in for any considerable period, cause an irritation of the connective-tissue cells in the liver surrounding the portal radicles. A proliferation of the same occurs, and, as a final effect, contraction of this newly formed tissue—as is the case with all newly formed connective tissues—ensues, producing the so-called cirrhotic or hob-nailed liver. With the primary new formation there is naturally an increase in the size of the organ, while the secondary contraction causes an atrophy of the liver cells, (a) by direct pressure, and (β) by diminishing their normal blood supply. In those countries where the more dilute alcoholic drinks (wines and beers) are the national beverage, the cases of cirrhosis are unusual; while the contrary is true where the more concentrated drinks (brandy, whiskey, gin, or rum) are largely consumed. Finally, the portal radicles become so narrowed by the contraction of the connective tissue in which they lie that the portal circulation is interfered with, thus producing a mechanical congestion of the intestinal, peritoneal, and gastric capillaries, with ascites and watery stools.

Kidneys.—The alcohol being in a much less concentrated condition on reaching the kidneys than is the case with the liver, the effects, both physiological and pathological, are less marked. The watery portion of the urine is increased; the solid, at least so far as urea is concerned, is diminished. The increased amount of water excreted is a natural result of the increased blood pressure; the diminution of urea is due to the lessening of oxidation of the nitrogenous tissues. In these organs, also, the irritating results manifest themselves more slowly than in the liver, but in an exactly similar manner. Eventually the cirrhotic kidney is produced.

The effect of alcohol upon the skin is moderately to increase perspiration. This is a natural result of the cutaneous turgescence, but it is not known whether there is also a direct stimulation of secretion.

The temperature of the skin is temporarily raised by this turgescence, and the nerve endings are thus warmed. There is thus a false impression of warmth created, the general temperature actually falling quickly, and the individual being especially exposed to the evils of cold. In chronic alcoholism there is apt to be interstitial thickening of the integument.

In spite of the great amount of effort which has been concentrated upon the investigation of the systemic effects of alcohol, our conclusions are doubtful to a greater extent than in the case of almost any other drug.

There seems to be little room for question as to the ultimate net results, but a great deal of it as to the *modus operandi*. The indications are those of a drug which for a very brief period stimulates, then depresses the tissues upon which it acts. As to the depression, there is nowhere any question, but it is claimed by high authority that, but for the reflex stimulation already noticed, its effects upon the nervous system are wholly depressing, the apparent stimulation resulting from depression of the inhibitory and controlling functions. Undoubtedly this weakening of will power, and of the higher functions of coordination, play a very important part in the apparent manifestations of stimulation, and account for the great lack of uniformity in them in different individuals; yet it does not seem possible to account so well in any other way for the symptoms as by assuming the existence of a primary stimulation. In a practical study like the present, it seems more profitable to discuss the conspicuous net results, and to avoid extended discussion of the mechanism.

The peculiar interaction between the effects of alcohol upon the circulation and those upon the nervous system renders it difficult to consider either without having first taken up the other.

As a result of the systemic effect of alcohol, the rate, and to a greater extent the force, of the heart, are increased, and this sufficiently to increase the blood pressure, in spite of the fact that there is marked arterial dilatation. This period is followed by one of depression, and the first stage is shorter, even almost altogether wanting, in proportion as the dose is increased. How far this result is due to depression of inhibition is one of the questions of greatest dissension among physiologists.

The same observation of an increase in respiration, and the same dispute as to its cause, are to be recorded. In any case, it seems clear that the result is not due to any direct central stimulation.

The chief nervous effects of alcohol are upon the brain, especially upon the cerebrum. Its action is delirifacient, there being a preliminary period of stimulation running into excitement. Even this stimulation is a narcotic one, being unequal, and resulting from the first in an interference with equilibrium. It is because this increased activity is due largely to inhibition of the powers of self control and restraint that the claim has been advanced that this is the sole cause, and that alcohol does not directly stimulate at all. It is quite evident, however, that such a result would necessarily follow the increased cerebral circulation due to general circulatory stimulation, even if there were not, as there appears to be, a direct primary stimulation of the cerebral cells. Only at the very beginning are the mental processes quickened, but after they have become slowed, and the mental processes blunted, the individual still believes them to be greatly improved. Despondency and mental pain are thus decreased, but the subject loses his judgment and becomes talkative and otherwise demonstrative and self-asserting. Intellectual, followed by sensory and motor paralysis then comes on, and the coma stage follows that of delirium. Paralysis of respiration and particularly of circulation may become complete, resulting in death. During the stage of depression, vomiting of central origin usually appears.

Alcohol is itself oxidized as a food, but decreases tissue oxidation. This may to some extent account for the reduced temperature, though this is chiefly due to the increased heat radiation resulting from engorgement of the superficial vessels. It is more rapidly oxidized under the influence of exercise, exposure to cold, and in fever. This is regarded as the normal method of its elimination, only five or ten per cent. of it being excreted by the kidney and lungs as alcohol. It is believed that this nutrient function does not at all relieve the demand for nitrogenous nutriment, but may to a great extent supply that for carbonaceous. The latter fact explains the accumulation of fat in alcoholic subjects, though their obesity is also favored by the decreased elimination of water which finally takes place.

The remote effects of alcohol may be good, but are far more likely to be harmful, due to excessive use, or to use continued beyond the period required. The general rule should be to use alcohol only temporarily. If used only to the extent of stimulating the digestion, it can result in great improvement of nutrition. But it may result in the complete destruction of digestion. If properly proportioned as to dosage, it is an excellent food in fever, but it may be used so as to exhaust the system. It can be used to benefit the excretory processes of skin and kidneys, but it may destroy either or both, resulting in cutaneous hypertrophies, or in nephritis. It is very apt to induce obesity, partly by interfering with the elimination of water, and partly by checking the oxidation of fat. It has a tendency to destroy fine cell structure everywhere. This is specially seen in the destruction of the finer moral and intellectual functions, in sensory and motor paralysis, and in reducing the parenchymatic liver tissue, with an increase of its fibrous portions. A peculiar kind of mania is induced by it, known as ***delirium tremens***, chiefly characterized by hallucinatious and delusions of snakes, demons, and other terrifying subjects. This appears to be connected with some peculiar form of malnutrition, as it never appears until after the loss of appetite has become pronounced. The ability of the system to withstand exposure, fatigue, or disease is slowly but most surely destroyed by alcoholism. This is especially noticed in pneumonia, which is almost certainly fatal to drunkards, although alcohol is one of the surest reliances in supporting pneumonic patients who have not been addicted to its use. Fatal acute poisoning by alcohol is not unknown, the effects pertaining especially to respiration in some cases, to circulation in others.

Various accidents are frequently mistaken for intoxication, especially apoplexy, coma from blows upon the head, and opium poisoning, and many scandals have originated from wrong diagnoses. The greatest care should be taken in the differential diagnosis of these cases.

The therapeutic local uses of alcohol are sufficiently indicated by our account of its local effects. Its uses as a digestant are undoubtedly its most important ones, if we regard the frequency of employment. Here the method of administration is of the utmost importance. It should not be used when any inflammation or irritation of the stomach exists. The smallest possible dose consistent with effectiveness should be employed. A teaspoonful to a tablespoonful of brandy or whiskey should suffice. The strength as imbibed should not be greater than five to fifteen per cent. It should be taken quickly just at the beginning or during the early part of the meal. If taken too soon, the effect is lost, and the liver may suffer. If taken too late, it interferes with digestion. Diluted alcohol is preferable to liquors, if one regards the danger of forming a habit. The administration should be carefully watched and skilfully controlled, and an effort made to decrease the dose almost from the beginning, and abandon it just as soon as possible. This is not only to avoid the formation of drinking habits, but to avoid inducing the stomach to depend upon the artificial stimulus.

Its next most important use is as a food. This may be at such times as ordinary food is not desired or not borne, but when food is imperatively required. It may then be taken by the stomach or the rectum. It will often aid in the digestion and assimilation of milk, besides contributing its own portion of nutriment. Therefore a milk punch is one of its most useful forms, but one of the most dangerous as to habit. In fever, it is useful in one, injurious in another class of cases. In a typical case, it should not only nourish the patient, but calm him, and reduce the fever. If the opposite effects are induced, it should not be used. Alcohol is a fairly good carminative, and brandy is astringent in many cases of diarrhœa; it is very difficult to say why. Insomnia may be relieved by alcohol, though there is a tendency to require its continued and increasing use, and this should under no circumstances be permitted. Gin is an

excellent diuretic, but the alcohol plays probably a subordinate part.

Alcohol, if taken in full dose and very early, especially with an abundance of water, is most valuable in breaking up an impending cold. It is readily conceivable that the most disastrous results may be thus avoided, when we consider the consequent transfer of blood from the viscera to the skin. The effect of the alcohol must in such cases be promptly supplemented by warm external applications, or at least protective coverings.

The various forms of alcohol can profitably be here considered, rather than to take them up in their regular alphabetical order in the different parts of this work. The alcoholic liquids of the different classes are as follows:

CARBONATED.—Kumyss is the weakest of all in alcohol. It is simply fermented milk. Mare's milk was originally used, but it is now very often substituted by cow's milk variously modified. It was originally fermented by the action of a special ferment, but yeast is now generally employed. It should be used while fresh, never more than four or five days old. It should contain about one and a half or two per cent. of alcohol, and be strongly carbonated. There are also traces of unknown ethers developed in the fermentation. It is estimated to contain about twelve per cent. of solid nutriment. It is soothing to the stomach, without in any degree retarding digestion. Its primary stimulating effect is followed by a slight soporific tendency.

Beer, Stout, Ale, and *Porter* are made from barley, the starch being first converted into sugar by the action of the diastase, under the influence of heat and moisture. In this condition it is *Malt.* The malt is subjected to a vinous fermentation. In making beer, this is done slowly at a low temperature, in the others more quickly, at a high temperature. The darker-colored stout and porter are made so by a partial burning of the materials. The percentage of alcohol ranges from two to nine, ordinarily about four or five. These liquors are abundantly carbonated and they contain more or less digestible nutriment. They appear also to exercise a small amount of digestive effect upon some foods. Hops or lupulin are added to genuine beer, but a great variety of bitter substances are in use, many of them selected without the slightest regard to their injurious effects upon the system, so that beer, if prescribed, should be always of a brand of known composition

Various other seeds, especially rice and peanuts, are similarly used, as well as many other starchy substances. Some savage tribes are ahead of us, in that they use substances which contain distinct medicinal constituents, together with the alcohol-yielding portion.

Wine, Cider, Pulque.—These are fermented vegetable juices, wine from the grape, cider from the apple, and pulque from the century plant. If used while still in the carbonated state, they are called "sweet" or sparkling, otherwise they are "hard" or "dry." In addition to the carbonic acid and alcohol, there are considerable amounts of sugar. When this amount is large, they are specially called "sweet." There are also considerable amounts of tartaric and acetic acids. When this is the case the wines are called "sour." A variable amount of tannin is present in red wines. Wines which have had the percentage of alcohol artificially increased are called "heavy" or "fortified," as port and sherry.

Vinum Rubrum, or *Red Wine,* U. S. P., is made from the entire grapes.

Vinum Album, or *White Wine,* U. S. P., is made from grapes from which the skins, seeds, and stems have been removed. Each contains from ten to fourteen per cent. of alcohol. A very large number of sugary fruits are utilized in the manufacture of special wines.

DISTILLED SPIRITUOUS LIQUORS.—Any fermented alcoholic liquor may have its alcohol distilled off. In this process various other substances are certain to come away with the alcohol, and their complete removal is very difficult, so that each kind of spirit will possess its characteristic color, odor, and taste. For the most part, however, these associated matters have not a high degree of physiological importance. Medicinally, the liquors are used chiefly for their alcohol, and there is little choice among them. The physician's responsibility in prescribing brandy, whiskey, and other pleasant forms of alcohol, and thus tending to promote alcoholic habits, is very great. In most cases, dilute alcohol or diluted deodorized alcohol, variously admixed so as to obscure its character or to make it less palatable, can frequently be employed with equal advantage. Because this is now so generally done by the more cautious class of physicians, and as there is so little genuine prescription demand for brandy and whiskey, it is seriously proposed to drop them from the Pharmacopœia.

Spiritus Vini Gallici, or *Brandy,* is distilled from wine, and contains thirty-nine to forty-seven per cent., by weight, of alcohol. There must be no admixture or modification of any kind, and it must be at least four years old. With the ordinary properties of its alcohol, it combines a distinctly astringent effect upon the bowels.

Spiritus Frumenti, or *Whiskey,* U. S. P., is similarly distilled from the fermented product, "mash," of grain, either rye or corn (the latter "Bourbon Whiskey"), or mixtures of them. It should be at least two years old and contain from forty-four to fifty per cent. of alcohol.

Gin is the equivalent of the compound spirit of juniper, already considered.

Upon keeping spirituous liquors, various ethers develop in them, which tend to make them pleasanter to the taste, but which do not materially modify the action of the alcohol.

The principal impurity of alcohol, especially of whiskey, is fusel oil, or Amylic Alcohol, next considered.

B. AMYLIC ALCOHOL.—(*Fusel Oil; Grain Oil; Potato Spirit Oil.*) ($C_5H_{11}HO$.)

In speaking of the alcoholic liquors, reference was made to fusel oil as one of the commonest of impurities. It can be obtained from all crude alcoholic liquids, and is removed from them in purification. It is chiefly obtained during the later portions of their distillation, and is much more abundant in spirits obtained from some sources than from others, notably from potato spirit. It is considerably heavier than pure ethyl alcohol (specific gravity 0.818) and its boiling point (128°–130° C.) is very much higher. It has an oily consistency, is colorless, has a powerful odor and a burning, acrid taste, the inhalation causing headache. Although amylic alcohol has very powerful physiological properties, it has never been much utilized in medicine, and it is used chiefly as a solvent in manufacturing operations It is a very powerful poison, the symptoms being those of great depression.

C. METHYLIC ALCOHOL.—(*Methyl Alcohol; Wood Alcohol; Wood Spirit; Wood Naphtha; Pyroxylic Spirit,* CH_3OH.)

In the crude pyroligneous acid distilled from wood (see *Acetic Acid*) there is about one per cent. of methyl alcohol, which is obtained by light distillation, after the addition of lime, and is then purified. It comes first in the series of alcohols, that is, it is the simplest of them. It has been found somewhat sedative, especially to the cough of consumptive patients, in doses of 1 to 3 c.c. (15 to 45 minims), yet it can scarcely be regarded as a medicinal substance. As it cannot be used as a beverage, ten per cent. of it is added to alcohol in England, to allow of the use of the latter in the arts without danger of defrauding the customs laws relating to spirituous beverages. This mixture is known as *Methylated Spirit.* Methyl alcohol is excellent for burning purposes, owing to its large percentage of carbon, and is relatively very cheap. It is one of the substances used in the manufacture of ether, and, through its acetone, of which it always contains considerable, of chloroform. Its chief uses are for the manufacture of formaldehyde and methyl chloride.

Henry H. Rusby.

ALDEHYDE.—The aldehydes form a genus of chemical compounds. Of this genus, *acetic* aldehyde is the commonest example, and accordingly the word aldehyde,

when used singly, is understood always to mean that substance. Acetic aldehyde, C_2H_4O, is, from the point of view of chemical composition, the first outcome of the oxidation of common—ethylic—alcohol. It resembles alcohol very closely in physical and physiological properties, being a thin, colorless fluid of pungent smell and taste; inflammable, miscible in all proportions with water, alcohol, and ether; antiseptic, irritant, and narcotic. It is not used in medicine. *Edward Curtis.*

ALDER, ALNUS.—(Brook alder; tag alder.) *Alnus* Tournef. is a genus of a dozen or more species in the family *Betulaceæ*, distributed through the north temperate zone, and extending along the mountains into the tropics. The bark and leaves are rich in tannin, and therefore strong astringents, without special character. They are used in tanning, and have numerous domestic medicinal uses, all depending upon the action of the tannin. Finely powdered, they have been found very useful by travellers for applying to chafed surfaces. The wood, deprived of the bark, makes a favorite charcoal for powder manufacture *H. H. Rusby*

ALDER, BLACK.—(Prinos winterberry.) The bark of *Ilex verticillata* Gray (fam. *Aquifoliaceæ*). (For the properties of other species of this large and interesting genus, the reader should consult *Maté*, *Holly*, and *Cassine*.) The plant under consideration is a large shrub, growing in hedges and borders of forests in the Northeastern United States, and displaying in fall and early winter slender branches densely covered with shining scarlet berries.

The bark is smooth, grayish or whitish ash-colored, and when dried for medicinal use is in "thin, slender fragments, about 1 mm. thick ($\frac{1}{25}$ inch), fragile, the outer surface brownish ash-colored, with whitish patches, and blackish dots and lines, the corky layer easily separating from the green tissue; inner surface pale greenish or yellowish; fracture short, tangentially striate; nearly inodorous, bitter, slightly astringent."

It contains tannin, resin, and an amaroid. No special physiological properties are known, but it has been used as a tonic and mild astringent The dose is 2 to 4 gm. (ʒ ss. to i.). *H. H. Rusby.*

ALEPPO BOIL.—(Oriental boil; Sahara chancre; Kandahar sore; Peudjet sore; Natal sore; Fr., Bouton de Biskra; Ger., Orientbeule.) Under these various titles has been described an affection endemic in certain districts of tropical and subtropical climates, the local names indicating many of the localities, chiefly in Algeria, Egypt, Syria, and Hindoostan, where it most commonly occurs. The disease is a local one, confined chiefly to the uncovered parts of the body, especially the face; the cheeks, angles of the mouth, eyelids, and alæ of the nose being the favorite seats. The scalp is never attacked, and while it may occasionally be located on the extremities, particularly the back of the hand and foot, it is rarely found on the trunk or pubes. In the vast majority of cases usually but one lesion manifests itself; but the lesions may be multiple. As many as fifty have been counted scattered over the face and body (Crocker). All who are brought within its influence are liable to the disease. It is most common in children between the second and seventh year, and in Aleppo it is considered almost as a matter of course that native children should have their "boil," few, if any, escaping.

It is more prevalent in autumn, when many insects are about, and Laveran has rather plausibly considered infection to be conveyed in this way. Others have considered the infecting agent to be contained in the water of the district, it gaining access to the body through some abrasion while washing or bathing, not by drinking the infected water. It has been definitely proven to be inoculable in both men and animals. It has not been shown, nor is there any reason for believing it to be hereditary One attack does not protect from recurrence or fresh inoculation Recovery is the rule, but always with a more or less disfiguring cicatrix, depending upon how early treatment is instituted.

The pathology is obscure, and nothing very definite has been demonstrated; and though there is a certain amount of evidence showing it to be an infective and destructive inflammation, due to a vegetable organism, the special organism has not as yet been isolated As has been said, it is a purely local disease unaccompanied by constitutional symptoms, but having a period of incubation varying from three or four days to several months; hence it may appear, in one who passes but a few days in the district, only after he has left it and is far distant from the place of contamination.

The first thing noticed is an itching in the part to be affected; then appears a reddish spot like a mosquito bite, developing in the centre a papule, which soon becomes conical, gradually enlarging to the size of a pea or bean and remaining of a terra-cotta red, smooth, and shining for some weeks or months. Then is noticed from the centre an oozing of clear serum, which dries into a yellowish-brown crust, extremely adherent. This crust, surrounded by a red areola, gradually enlarges as the process of disintegration beneath goes on, forming itself from the serum as it exudes from beneath the edges of the crust already formed.

This process of ulceration may go on until an area of several inches in diameter is reached, but usually half an inch or an inch in diameter is the average size attained. If the scab be removed, a round ulcer is disclosed with red indurated areola and more or less irregular, sharp-cut edges, base uneven, showing numerous yellowish points of ulceration with fungating granulations scattered unevenly over the surface. Ulceration may extend into the subcutaneous tissues. The ulcer secretes a thin, sero-purulent, offensive discharge, which, if allowed to, forms the thick adherent crust. After a period of some weeks or months extension ceases, and cicatrization takes place beneath the scab, which finally drops off, leaving a more or less puckered, brown, pigmented scar, the process from beginning to end lasting from six months to a year, sometimes longer. Lymphangitis, erysipelas, and neighboring glandular enlargements are occasional complications.

The best thing in the way of treatment is to let the thing alone, preserving the scab carefully *in situ*, and allowing healing to take place under it. If the scab fall, the ulcer should be treated with the methods usual when dealing with a simple ulcer. If seen in the early "mosquito-bite stage," which is seldom, the actual cautery has been recommended. By way of prophylaxis, one should carefully look after any possible excoriations of the integument, avoiding the infected water for toilet purposes, unless previously boiled.

Charles T. Dade.

ALETRIS.—(Unicorn root, star grass; mealy starwort; colic root. Sometimes erroneously called blazing-star.)

The rhizome of *Aletris farinosa* L. (fam. *Liliaceæ*). This plant is a low, slender, erect, perennial herb, common in swamps and low lands east of the Mississippi River. It has been much used in domestic practice as an abdominal stimulant. It contains an unknown bitter principle, soluble in alcohol and somewhat in water. The use of the drug is purely empirical—in colic and rheumatism. The fluid extract is the best form of administration, and is given in doses of 0.5 to 1 c.c. (♏ viij.–xv.).

Seven other species of Aletris are known, one in the Southern States and six in Eastern Asia, but their properties have not been investigated. *H. H. Rusby.*

ALGIERS.—Algiers, the largest town and capital city of the French colony of Algeria, lies almost due south of Marseilles, upon the Mediterranean coast of Africa (lat. 36° 47′ 20″ N., long. 3° 4′ 32″ E.). The population in 1866 was 52,614. As seen from the deck of an approaching steamer, the appearance of the city is exceedingly picturesque and striking, its compact mass of dazzlingly white houses having the form of a triangle, whose base

rests upon the western shore of the bay, while its apex climbs almost to the summit of the range of hills shutting in the bay on that side, and culminates at the Kasbah, or former palace of the deys, some five hundred feet above the level of the sea.

Running along the water line of the city is a well-built quay, backed by a series of stone arches which support a wide and handsome promenade terrace, or boulevard. The Place du Gouvernement and the neighboring streets constitute, together with this quay and esplanade, the newer part of the town built by the French, and occupied by public buildings, warehouses, and the residences of some of the foreign inhabitants. Mustapha Superior, a very pretty suburb lying on the hillside east of the city, contains many villas, and is probably the most desirable place of residence for invalids intending to pass a winter at Algiers. Another suburb, lying also to the east of the town, is known as Mustapha Inferior, just beyond which, at a distance of two miles from Algiers, is situated the great Jardin d'Essai, an experimental garden under the management of the French government, wherein many varieties of palms and other tropical plants are to be seen growing in the open air. Ste. Eugenie, another suburb of Algiers, also contains villas, but of a residence in these Dr. Bennet ("Winter and Spring on the Shores of the Mediterranean") speaks unfavorably, stating that "they are decidedly objectionable, being at the extremity of the western promontory that contributes to form the bay of Algiers, and exposed, consequently, both to the northwest and northeast winds." As to that portion of the city proper, the old quarter, which climbs the hill back of the French quarter previously described, it is not for a moment to be thought of as a residence for invalids, consisting, as it does, of a compact mass of low, flat-roofed whitewashed houses, intersected by the narrow, crooked, dark, and dirty streets characteristic of an Oriental town. Picturesque, indeed, this portion of the city may justly be considered, and a ramble through its dingy streets will well repay the traveller for whom the typical scenes of Eastern life possess a fascination; but with its picturesqueness its attraction for the visitor certainly ends.

From its low latitude and its situation within the great Mediterranean basin, as well as from its proximity to the desert of Sahara, the climate of Algiers is necessarily a mild one in winter and a hot and very dry one in summer, having its rainfall confined almost exclusively to the colder months of the year, as is the case with all places lying in the subtropical region of the Old World. The greater mildness of its winter climate, as compared with that of the Genoese Riviera, is ascribed by Dr. Bennet, in large measure, to the higher temperature of the hours between sunset and sunrise, the temperature along the Riviera being lowered at night "by down-draughts from the mountains that protect it from the north, the Maritime Alps." Another element in producing this more equable temperature at Algiers is probably the fact that winds blowing from the north must pass over the warm waters of the Mediterranean before they can reach the African coast, whereas on the northern shores of this sea all such winds partake of the character of continental winds, and, notably in the case of the much-dreaded *mistral* of the Rhone valley and of the *bora* of the upper Adriatic, they are accompanied by sudden and most uncomfortable depression of the atmospheric temperature.

The following data, representing the climatic features of Algiers, have been collected from various sources: The mean annual temperature is 66.5° F., according to the writer in the Encyclopædia Britannica; 67.89° F., according to Martin and Folley, quoted by Dr. H. C. Lombard, in his "Traité de climatologie médicale"; 64.58° F., according to Angot, quoted by Dr. Julius Hann, in his "Handbuch der Klimatologie"; 69.13° F., according to the author of the article on "Climate," in the "Nouveau Dictionnaire de médecine et de chirurgie" (Jules Rochard); and, finally, about 68° F., according to Dr. Herman Weber. The mean of all these figures would give us 67.22° F. as the mean annual temperature of Algiers. On page 448 of his work above cited, Dr. Hann states as follows: "Entirely erroneous mean temperatures have hitherto [1883] been given for Algiers, which showed especially a winter temperature by far too high. The figures of our table are quoted from a recently published work by Angot, and relate to the period between 1860 and 1879." For the eight months of August, October, November, December, January, February, March, and April the figures of Dr. Hann are as follows:

Aug.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.
77°	67.46°	60.44°	54.68°	53.78°	54.68°	57.02°	61.34°

The mean absolute minimum temperature, he states (on the authority of Angot) to be 38.48° F. Deducing from the above-given figures the mean temperature of the three winter months, we find it to be 54.38° F., while that of the seven colder months of the year (October to April) is 58.48° F. The duration of the season for invalids ("Kurzeit"), according to Weber, is from November until the end of April; for this period of six months the average temperature of Algiers, calculated from these same figures, is 56.99° F. There appears to be much difference of opinion respecting the degree of variability of temperature exhibited from day to day. Thus, the writer in Eulenburg's "Encyclopädie" remarks that the changes in temperature during the course of a single day, from one day to another, and from one month to another, are considerable in their amount, and frequently sudden in their manner of occurrence (sind sehr bedeutend und fallen oft sehr plötzlich ein). Weber (*loc. cit.*) says the daily variations are from 10.8° to 14.4° F. (6° to 8° C.). Rochard (*loc. cit.*) states that the annual mean of the variation from day to day does not exceed 11.34° F. (6.3° C.), while the difference between the day and night temperatures (variations nycthémérales) is given by him at from 5.4° to 9° F. (3° to 5° C.). Lombard remarks that the former (variations diurnes) are not extreme, not exceeding 1.45° F. in winter, 2.03° F. in spring, 2.66° F. in summer, and 1.6° F. in autumn. The absolute minimum temperature observed at Algiers during a period of twenty years was 35.6° F., according to the author last quoted.

The following figures for the relative humidity are given by Dr. Hann:

Nov.	Dec.	Jan.	Feb.	March.	Winter Mean. Dec.-Feb.
68	73	73	72	69	73

The extreme figures representing this factor of climate during the whole year are given as sixteen per cent. and eighty per cent. (Mitchell, quoted by Rochard).

The annual rainfall at Algiers is about 36 inches; Lombard puts it at from 31.49 to 33.7 inches, and gives the following extreme quantities: 21.9 and 42.3 inches. As illustrating the seasonal distribution of the rainfall, the following tables, quoted by Dr. Bennet, will be of interest to the reader:

A.—MEAN RAINFALL AT ALGIERS, 1839-1845.

November	5 inches.	May	$1\frac{1}{4}$ inch.
December	8 "	June	$0\frac{1}{4}$ "
January	6 "	July	0 "
February	5 "	August	$0\frac{1}{4}$ "
March	3 "	September	1 "
April	4 "	October	$2\frac{1}{4}$ inches.
Total	31 inches.	Total	5 inches.

B.—NUMBER OF DAYS AND NIGHTS IN 1843 ON WHICH RAIN FELL.

	Days.	Nights.		Days.	Nights.
November	10	10	May	3	1
December	5	2	June	2	0
January	10	7	July	0	0
February	9	7	August	0	0
March	9	6	September	2	0
April	1	2	October	3	1
Total	44	34	Total	10	2

It will be observed that the mean rainfall for October given in Table A is but little less than that for March, thus bearing out the statement made by Dr. Hann that the duration of the dry season for places lying on the Algerine coast is but five months. The average number of fair days in the course of a year at Algiers is two hundred and thirty-three. The prevailing wind for the year is the northwest, which frequently blows with great violence. The west is the rain-bearing wind, and is the one which is of commonest occurrence in the winter season. North and northeast winds are those which blow most frequently during the spring and summer months. The sirocco, taking its origin over the heated sands of the great Sahara desert, is most commonly felt at Algiers during the hot season, at which time it is greatly dreaded. This wind, blowing from the southeast, occurs somewhat less frequently during the colder months, at which season it is far less oppressive, and is more easily borne. The sirocco at Algiers is always a dry wind; it is accompanied by clouds of dust, a portion of which, consisting of extremely fine particles of sand, it brings with it from the great desert. Dust, it may be remembered, is one of the pests of the Algerine climate; in great part it is of purely local origin, the character of the soil and the heat of the sun, together with the almost constant prevalence of wind, favoring rapid evaporation of the rainfall, and the rainfall itself occurring chiefly in the form of heavy and not very protracted showers. A fall of snow at the city of Algiers itself is an extremely rare phenomenon, in the elevated country back from the coast, known as the Hauts Plateaux, snow falls quite frequently, and at times to a considerable depth. The water supply of the city of Algiers is abundant. Concerning the character of the water, the writer has no exact information; but from the absence of adverse comments in the works of the various authors consulted, he deems it probable that it possesses no deleterious qualities.

The mildness of its winter climate, together with the moderate percentage of relative humidity in the atmosphere, and the great preponderance of clear skies and of bright, sunny weather, which it enjoys at all seasons, combine to render Algiers a desirable, pleasant, and beneficial place of residence during the winter and early spring months, for invalids suffering from pulmonary phthisis and from certain other affections of the respiratory system. For such cases its climate is recommended by Lombard, Rochard, and Weber. The last-mentioned writer speaks of the climate as exercising also a beneficial influence upon chronic diarrhœas and upon the sequelæ of dysentery.* Lombard specifies chronic bronchitis, asthma, and phthisis as diseases likely to be benefited by a sojourn at Algiers, and he calls attention to the remarkable immunity from pulmonary phthisis enjoyed by the native population, as well as by the soldiers of the French army stationed in Algeria. This immunity is greater upon the seacoast than it is on the higher ground lying farther inland. The writer on Algiers in Eulenburg's "Encyclopädie" speaks, on the contrary, in very unflattering terms both of the climate of the city and of its desirability as a winter residence for invalids. He lays great stress upon the variability of the climate and its liability to sudden changes of weather, and warns all invalids who are unpleasantly affected by such changes, all asthmatics and persons subject to attacks of diarrhœa, rheumatism, and intermittent fever, that they would do well to avoid the place. How far the unfavorable comments of this writer may be justified, the writer is not in a position to know from personal experience; but, judging from the meteorological data quoted from reliable sources in the present article, and from the favorable comments made by Lombard and other writers of repute, he deems it not improbable that the contributor of the article in Eulenburg's "Encylopädie" has overestimated the unpleasant features of the Algerine climate.

Huntington Richards.

[Dr. Charles Theodore Williams, in "Aëro-Therapeutics," 1894, speaks as follows from his personal experience:

"Of the dozen consumptive patients of whom I have notes who have wintered once or oftener at Algiers, the large majority improved greatly, and number at least two cases of arrest; but I note that the greatest improvement took place where patients resided in villas with gardens, and not in hotels. In one case, where a young lady, a member of a very consumptive family, developed the disease and a considerable cavity had formed in one lung, complete contraction of the cavity took place with arrest of the disease in two winters, and the lady has since married and has resided for the last nineteen years in England without any signs or symptoms of relapse. Another lady, with well-marked tuberculosis of one lung, spent two winters in a villa at Mustapha Supérieur, with the result that the disease became arrested, and since that date she has been able to pass twelve winters in Scotland with impunity."

Strictly speaking, no moderately moist, warm marine climate like Algiers can be considered especially curative for phthisis, except on Dettweiler's general principle that phthisis can be cured in any climate where there is pure air and a freedom from dust and wind. Undoubtedly, such a climate has its value for certain cases of phthisis of low vitality and nervous irritability, and also for those patients who are unable to adapt themselves to the climatic conditions of the high resorts.

Such a climate is also valuable for patients with chronic bronchitis, and with emphysema, and for those who are in the early days of convalescing from pneumonia. *E. O. O.*]

ALHAMBRA SPRINGS.—Jefferson County, Montana.

Post-Office.—Alhambra

Access.—Via Northern Pacific or Great Northern Railroad. Hotel.

These springs are located fifteen miles from Helena, at a level of 3,786 feet above the sea, the surrounding country being broken and mountainous. A dry and salubrious climate, with varied and picturesque scenery, characterizes this region. The hills and mountains are covered by different varieties of pine, fir, and cypress, while the bottoms are dotted with groves of alder, willow, mountain ash, poplar, and other trees. Many varieties of plants have been found in the neighborhood, which, it is said, have never yet been classified. Game is still abundant, consisting of grouse, pheasants, deer, elk, mountain lions, and a few bisons. The springs are situated in an angle formed by the junction of two creeks, in which mountain trout abound. They are twenty-two in number, and vary in temperature from 90° to 134° F. A complete analysis has never been made, but Dr. Stein, the proprietor, supplies the following partial qualitative analysis made by himself:

Sodium carbonate,	Lithium carbonate,
Potassium carbonate,	Sodium chloride,
Calcium carbonate,	Potassium sulphate.

One spring is said to be strongly chalybeate, while another is heavily impregnated with fluoride of calcium. We are unable to classify the waters by the above analysis. A sufficient quantity from some of the springs produces mild purgative effects in most people.

Dr. Stein states that the internal use of the waters is markedly advantageous in cases of chronic articular rheumatism, and in other disorders for which the Carlsbad waters of Bohemia have become famous. Mild attacks of albuminuria usually disappear, and even advanced cases of Bright's disease are benefited. Abundant facilities for hot and cold bathing, with a plunge and swimming bath, are provided. *James K. Crook.*

*Chronische Bronchitis, besonders mit Reizhusten, Emphysem, Ueberreste von Pneumonie und Pleuritis und Phthisis im ersten Anfang bilden das geeignete Material; auch chronische Diarrhöen und Folgezustände von Dysenterien sind geeignet (Ziemssen's Handbuch der allgemeinen Therapie, Bd. ii., S. 80).

ALHUELICAN SPRING.—Situation, west of the city of Tehuacan, capital of the district of the same name, in the state of Puebla, two and a half kilometres from Tehuacan. Transportation, by way of the Mexican Southern Railroad.

Chemical composition (Dr. F. Villaseñor):

Hydrometric degree	52°
Hydrometric degree after boiling	30°

Solids.	Gm. per Litre.
Sulphate of lime	0.0770
Sulphate of magnesia	0.2875
Carbonate of lime	0.2215
Carbonate of earthy salts	0.5860
Chloride of sodium	0.1675
Traces of iron, inorganic matters, silica, and undetermined substances, differential	0.0845
Saline residue dried at 120° C	0.8380
Total	2.2620

Gases at 0° and at 0.76° C.

Gases.	c.c.
Carbonic acid	27.730
Oxygen	13.499
Nitrogen	36.600
Total	76.829

USES.—The composition of these waters being similar to that of the Carlsbad waters, they have been employed in the treatment of the same conditions, and more particularly for the relief of cholelithiasis; and from time immemorial they have enjoyed a great reputation in the treatment of the latter condition. Several physicians recommend them highly, but perhaps the one who has done most to generalize their use is Dr. D. Mejia, professor of internal medicine in the Medical School of Mexico. Dr. Martinez Frey, resident practitioner in Tehuacan, prescribes them in the following manner:

From 120 to 160 gm. per dose four times a day as follows: the first, on an empty stomach, lukewarm; the second at 10 A.M.; the third at 5 P.M.; the fourth at bedtime. All these doses are to be taken in small mouthfuls, the patient furthermore being at liberty to take them at meal times as well, under certain restrictions. An excessive use of the water is to be avoided. By pursuing this method and by regulating the patient's diet, Dr. Frey has brought about many cures within periods varying from three to four months.

During the first few days the water has a purgative effect, but the system rapidly acquires tolerance for it, to such an extent indeed that in spite of its composition it serves as the drinking water of Tehuacan, where the inhabitants generally enjoy good health and are long-lived.

It appears that its prolonged use tends to produce constipation.

Among the inhabitants of Tehuacan, cholelithiasis is of rare occurrence, a circumstance which may perhaps be attributed to the fact that they never drink any other water. *N. J. Ponce de Léon.*

ALICANTE.—Spain. This city of 36,000 inhabitants lies upon the shore of the bay bearing the same name, on the eastern or Mediterranean coast of Spain, and about forty miles south of the middle point of that coast (lat. 38° 20′ N., long. 0° 30′ W.). Extending in the form of a crescent along the northern shore or head of the bay, and dominated by a rocky hill, some four hundred feet high, the town is tolerably well sheltered from the north and northwest winds, the bay being open only to the westerly winds. "The landward environs are dreary," says Baedeker; "but the distant mountains, the castle, the harbor, and the sea combine to form a memorable picture." "The view from the east mole of the harbor," continues the same authority, "with its white, flat-roofed houses, its palms, and the bare and tawny cliffs of the castle hill, has probably no parallel in Europe."

The climate is a mild and dry one, drier than the Riviera, the annual rainfall being only 16.93 inches, of which (according to Lorenz and Rothe, quoted by Dr. Weber, in Ziemssen's "Handbook of General Therapeutics") 20.7 per cent., or the extremely small quantity of 3.5 inches, falls during the winter months. The percentage of clouds prevailing in the sky of that portion of Spain in which Alicante is situated is much lower than is found in any other part of Europe, Italy and Greece included. The relative humidity of Alicante the writer has not been able to ascertain; but at Valencia, some eighty-five miles north of Alicante, the mean yearly relative humidity is 66°, and it is probably somewhat less at Alicante. The mean annual temperature is 64.4° F.; that of winter being 53.5° F. Another authority gives the mean winter temperature as 60° F. There is no mistral or dust.

The present condition of the water supply is not known to the writer; it is probably the same as when Dr. Bennet wrote of it in 1875, which consisted then of a large spring and rain water tank. The accommodations are said by Dr. Weber to be good. The wine of Alicante is famous, and, besides a large commerce, the town possesses an extensive tobacco factory, which employs four hundred Spanish girls.

Dr. Weber speaks from personal experience of a few cases of arrested phthisis without pyrexia doing well here during a sojourn of several months. When a mild, dry, and sunny climate is considered desirable for early pulmonary tuberculosis, Alicante would seem admirably to fulfil these conditions. Cases of latent scrofula, asthma, bronchorrhœa, albuminuria, and rheumatism are also said to do well here. *Edward O. Otis.*

ALIMENT.—Food or aliment is matter which, in conjunction with the air, supplies the elements necessary for the maintenance, growth, and development of the organism, and is thus the source of the power on which the vitality of the organism is dependent—*i.e.*, the source of the heat, mechanical work, and other forms of energy liberated in the body. Hence, in the broadest sense, true aliment is a mixture of food stuffs and drink, together with the air, from which comes the oxygen necessary for the oxidation of the former and by which energy is liberated. Again, physiologically considered, true aliment, especially in the animal kingdom, is to be distinguished from so-called "food" as being only that portion of the food which is either directly available for absorption, or convertible by the digestive juices of the body into soluble and more or less diffusible products, capable of being absorbed by the blood and lymph.

The food of vegetable organisms is quite different from that of animal organisms. Moreover, the nature of the processes involved is likewise quite different.[1] The vegetable organism, by a synthetical process—a building up of more complex bodies from simpler ones—derives its nourishment from the inorganic world; its cells appropriate such of the inorganic principles as are needed for its growth, and convert them under the influence of the sun's rays into organic compounds which enter into its own structure.

The animal organism, on the other hand, does not possess this power, and thus we look to the creative power of the vegetable kingdom as the source, either directly or indirectly, of the aliment of animals. Moreover, the vegetable matter which thus serves as food not only furnishes the material necessary for the growth and life of the organism, but it contains, in addition, stored up within its molecules, a certain amount of latent force derived from the solar force originally used in its construction.

Animal organisms, by a process of transformation quite the reverse of synthetical, convert the preformed animal or vegetable organic matter into allied or simpler forms, which are absorbed into their own tissues. Animal food, approximating more closely in composition with the body to be nourished by it, is perhaps more easily appropriated, and probably with less expenditure of energy, than vegetable products. Animal food, moreover, possesses stimulating properties, due, without doubt, to the crystalline nitrogenous bodies contained in muscle serum. Organic matter once entered as a part of an animal organism and applied to the purposes of life is decomposed or

broken apart, and its decomposition products are ultimately reconverted into inorganic principles. There is thus a complemental relationship between vegetable and animal life and the inorganic world. The plant, by a selective action, appropriates as an element of nutrition certain kinds of mineral matter, together with nitrogen in the form of ammonia and nitrates, from the soil in which it grows, at the same time drawing from the air carbon in the shape of carbonic acid, while hydrogen and oxygen are supplied to an unlimited extent in the form of water. The vegetable products thus formed serve in turn as the food of animals, while the latter at every breath pour forth carbonic acid and water, which ultimately find their way again, more or less modified, into the tissues of plants. These, together with the nitrogenous excreta, products of the metabolism of life, and the post-mortem decompositions which follow, continually serve in their variously modified forms as agents by which the conservation and transference of energy is accomplished.

Now, since food is the source from which the various elements of the body are supplied, it is evident that to fulfil its purposes food must contain all of the elements present in the body. These are, of course, not free, but in a state of combination, for it is only in the latter case that they are of service as food, and, as Pavy remarks, "the combination must have been formed by the agency of a living organism—the combination must, in other words, constitute an organic product." Aside from the elements which appear as inorganic salts, there are in the body at the most but six elements, two of which are present only in small quantity and are apparently less important. These six elements are carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus. Any substance which as food is to satisfy the requirements of life, must contain at least the first four of these six elements, in addition to inorganic salts and water.

The alimentary products found in nature can be separated by chemical analysis into several well-defined substances, none of which are usually found free in nature. These chemically distinct substances are termed the alimentary principles. Many of them are found in both animal and vegetable foods, as, for example, certain fats and some forms of proteid matter, although in the case of the latter example there would appear to be some few minor points of difference both in percentage composition and in chemical reactions between the corresponding substances of animal and vegetable origin. Others are to be found only in one kingdom, as starch in the vegetable, or collagen, the gelatin-forming substance, in the animal.

Various classifications of food have been from time to time proposed, based mainly upon either physiological or chemical grounds. Popularly, aliment is frequently divided into food and drink, without, however, any suitable reasons, since the mere fact of a food being in solution does not preclude the possibility of the presence of even a large amount of solid matter, as, for example, in the case of milk; while, on the other hand, butcher's meat contains on an average sixty to seventy-two per cent. of water. Hence food should be considered as including both liquid and solid matter. The most natural and comprehensive classification of foods is that based primarily on chemical composition and origin, viz., organic and inorganic—that is, chemical combinations of elements producible chiefly through the agency of living cells; and secondly, inorganic compounds absorbed from the mineral kingdom, and thus intimately mixed with the former. The inorganic portion of food consists simply of water and various saline compounds. The organic portion may be advantageously subdivided into two groups, nitrogenous and non-nitrogenous, based mainly on the presence or absence of the element nitrogen. The nitrogenous alimentary principles, represented chiefly by proteid or albuminous substances, contain carbon, hydrogen, oxygen, and nitrogen combined in varying proportions, and generally also small quantities of sulphur and frequently of phosphorus. The non-nitrogenous principles contain only the three elements, carbon, hydrogen, and oxygen. These are in turn further subdivided, according to the relative proportion with which the carbon and hydrogen unite with oxygen—viz., into fats and carbohydrates; the former consisting of carbon and hydrogen united to only a small amount of oxygen, as in the case of tripalmitin, $C_{51}H_{98}O_6$; the latter of carbon, with the hydrogen and oxygen always in such proportion as to form water, as in the case of cane sugar or saccharose, $C_{12}H_{22}O_{11}$; hence the name carbohydrates. These two divisions of the non-nitrogenous principles not only differ in percentage composition, but they are likewise widely divergent both in chemical and in physical properties. Following is a partial classification of foods:

- 1. INORGANIC.
  - (a) water.
  - (b) salts.
    - calcium sulphate and phosphate.
    - magnesium sulphate.
    - potassium chloride, phosphate, and carbonate.
    - sodium chloride, phosphate, and carbonate.
    - iron salts.
    - silica, fluorine.
- 2. ORGANIC.
  - (a) non-nitrogenous.
    - fats.
      - tristearin.
      - tripalmitin.
      - triolein.
      - } animal and vegetable.
    - carbohydrates.
      - amylaceous.
        - starches.
        - gums.
        - dextrins.
        - cellulose.
      - saccharine.
        - grape sugar.
        - cane sugar.
        - milk sugar.
        - maltose.
  - (b) nitrogenous.
    - gelatinous principles.
      - collagen.
      - chondrigen.
      - gelatin.
    - albuminous principles.
      - albumin.
      - fibrin.
      - syntonin.
      - globulin.
      - } animal and vegetable.
      - nucleo-proteids.
      - casein.
      - elastin, etc.
    - amido-acids and nitrogenous bases.
      - asparagin.
      - creatin.
      - leucin, etc.
      - xanthin.
      - hypoxanthin, etc.

Examination of this classification leads us first to notice the importance of water[2] as food. According to Voit,[3] the body of a fully developed man contains 63 per cent. of water, while the body of a growing child contains nearly 66.5 per cent. Any great alteration in the content of water in the animal body is always attended with disastrous results; thus, in diarrhœa, cholera, etc., such large quantities of water are lost as to render the blood quite thick, and even the muscles may lose as much as six per cent. of water. Such loss, if long continued, soon results in loss of vitality and consequent death. It is noticeable, moreover, that a certain proportion of the water contained in the tissues of the body can be removed without difficulty, while a smaller, residual portion, apparently more closely united to the organic matter, can be separated only with great difficulty; this is well illustrated in the simple drying of dead muscle tissue. Removal of the water from low forms of animal life, by drying them at the ordinary temperature, or at a temperature below the coagulating point of their body protoplasm, causes them to lose all appearance of life; but in such condition they will again absorb the water lost, and return to their former appearance and vitality. Increase of water in the organism beyond the normal amount is usually associated with an unhealthy condition of the body. Various investigators have likewise demonstrated that there is a close connection between the percentage of water in the body and the diet, irrespective of the water taken as drink. Thus Voit has shown that a bread diet, continued for some time, renders the body more watery than normal. In one experiment with a cat, the amount of water in the brain and muscles was increased three to four per cent. Increase of fat in the body is usually attended with a diminished percentage of water.[4] A vigorous, well-nourished man possesses or-

gans much poorer in water than a badly fed person. Forster[5] has figured that under normal conditions a person living on an average diet takes daily from 2,215 to 3,538 gm. (about 6.5 pounds avoirdupois) of water. It is easy to see, however, that a great variety of circumstances, as variations of diet, exercise, temperature, etc., may have a modifying influence on the amount of water taken into the system during the twenty-four hours. The figures just given do not, however, represent all of the water, since a variable amount is formed within the body by oxidation of the hydrogen contained in the organic alimentary principles. Thus, according to Voit, in the case of a hungry man, 32 gm. of hydrogen in the form of organic matter were oxidized to 288 gm. of water during twenty-four hours.

It is thus plainly evident from the foregoing that water is a necessary constituent of the body, and as one of the alimentary principles is a decidedly important one; yet we need to understand its true significance. It does not itself undergo any chemical change, and is not a source of energy, though it aids chemical change in supplying, by its presence, a condition absolutely necessary for its occurrence in other bodies.

The inorganic salts, as Pavy remarks, "stand, if not to the full extent, nearly so, in the same position as water, as regards the non-possession in itself of force-producing properties." The mineral matters are more closely concerned in the structure of the organism than in the liberation of energy, and this is true both of animal and vegetable organisms. Further, inorganic salts appear to play an important part in regulating and controlling in some measure the various metabolic processes of the body, although they themselves contain little or no potential energy. They are particularly necessary in the developing animal body, and of all the forms of mineral matter none is so important and so widely distributed as calcium phosphate. This salt is seldom, if ever, absent from any structural element of the body, and its intimate union with many of the nitrogenous principles, particularly the albuminous bodies, is so decided that only with the greatest care can this salt be completely removed without changing the nature of the albuminous body;[6] indeed, in many cases there would appear to be a chemical combination between the proteid body and the inorganic salt. Mineral matter is needed not only for the growth and nutrition of the skeletal portions of the body, but it is also needed in the structure of the softer tissues, as well as in the formation of secretions; thus, the acid of the gastric juice has its origin in the chlorine of sodium chloride, or common salt, while the alkalinity of the pancreatic secretion, as well as that of some of the other fluids of the body, is due mainly to inorganic salts, as the alkali phosphates and perhaps bicarbonates. Moreover, the removal of carbonic acid by the lungs, through the agency of the venous blood, could hardly be accomplished were it not for the alkalinity of that fluid. In many juices of the body, inorganic elements are held not only in solution, but quite firmly united with the more characteristic matter, as in the sodium salts of the bile acids, and in some instances they can be removed only by decomposition of the compound. The excess of salts taken into the body, by the food or other means, and that which becomes free by decomposition within the body, is easily removed through the urine and fæces.

There is still other evidence that the various inorganic salts of food serve definite purposes in the body. The two alkalies, potash and soda, so widely distributed and so closely allied in their chemical properties, cannot be made to replace each other in the living organism, while the same is likewise true, to a certain extent, of the alkali earths, lime and magnesia. Thus a qualitative, and also a quantitative, selection of inorganic matter is noticeable in the body, particularly in the blood, where the corpuscles contain the greater portion of the potassium salts and phosphates, while in the serum, sodium salts and chlorides are in excess. Again, it is quite noticeable that potassium salts predominate in the formed tissues of the body, while sodium salts are characteristic of the fluids.

Forster's[7] experiments on pigeons with food poor in salts, and on dogs with powdered meat from which the greater portion of inorganic matter had been removed by extraction with hot water, fat and carbohydrates being afterward added, showed that these animals could not bear the loss longer than four to five weeks without great suffering, and, finally, death. In fact, it is evident, from physiological experiment, that an organism supplied with all organic food stuffs and water can live only for a limited time without mineral matter For a time the body draws upon the inorganic matter stored up in its own tissue;[8] but this failing, and that naturally present in the organic foods being removed, death soon results from lack of inorganic aliment.[9] In the ordinary diet of men and animals, sufficient salts are generally contained in the non-nitrogenous and proteid foods to furnish the required amount of mineral matter. As to the actual quantity of inorganic matter needed to counterbalance that withdrawn from the body in twenty-four hours, we can hardly say. The content of ash contained in the smallest amount of food necessary to keep up the vitality of an organism would give an approximate answer to this question. This Bischoff and Voit attempted to ascertain by experimenting with a dog weighing 31 kgm. (68.3 pounds), the daily food in this case containing 6.5 gm. (gr. 100.3) of ash. The excretion of mineral matter, however, as Voit has pointed out, is quite different in the hunger condition from what it is during a plentiful diet; for, in the case of hunger, the inorganic matter of the organs is drawn upon, the salts passing into the excreta, thus keeping the percentage composition of these fluids for a time constant.

The importance of iron, or iron salts, as aliment, is hardly second, certainly not in the case of the higher animals, to lime salts. The position which it occupies in the hæmoglobin molecule, on which the blood depends for its power of carrying oxygen, would alone indicate this. Boussingault[10] has determined the amount of iron in a sheep of 32 kgm. weight to be 3.38 gm., = 0.151 per cent.[11] It is to be borne in mind, however, that much of the iron taken as food is consumed in the form of organic compounds, as in hæmoglobin, ferruginous nucleo-proteids, nucleins, etc.[12]

The following table[13] shows the amount of inorganic constituents present in some foods, the figures expressing parts per one hundred of the *dry* substance:

	K_2O	Na_2O	CaO	MgO	Fe_2O_3	P_2O_5	Cl
Beef	1.66	0.32	0.029	0.15	0.020	1.83	0.28
Wheat	0.62	0.06	0.065	0.24	0.026	0.94	?
Potato	2.28	0.11	0.100	0.19	0.042	0.64	0.13
White of egg	1.44	1.45	0.130	0.13	0.026	0.20	1.32
Peas	1.13	0.03	0.137	0.22	0.024	0.99	?
Human milk	0.58	0.17	0.243	0.05	0.003	0.35	0.32
Yolk of egg	0.27	0.17	0.380	0.06	0.040	1.90	0.35
Cow's milk	1.67	1.05	1.510	0.20	0.003	1.86	1.60

Of the non-nitrogenous foods, the fats which, according to the old-time classification of Liebig, come under the head of respiratory or calorifacient principles, are particularly applied to the production of heat and other forms of energy. They also appear to be concerned, to a certain extent, in tissue development. The neutral fats alone are important as foods. The free fatty acids and glycerin are seldom present in sufficient quantity to have any significance. The more important fats are tristearin and tripalmitin among the solid, while among the more easily melting fats triolein is the chief representative. These are simply neutral compounds, formed by the union of a triatomic alcohol, glycerin, with three molecules of a monatomic fatty acid. The fluidity of a fat depends on the amount of olein present; thus, beef fat, which contains more palmitin and stearin, melts at 41° to 50° C., while goose fat, which contains large quantities of olein, melts at 24° to 26° C. The following

table gives some idea of the amount of fat contained in a few common foods:

	Per cent. of fat.
Fat tissue of swine	92.21
Fat tissue of beef	88.88
Fat tissue of mutton	87.88
Butter	85.0 to 90.0
Eggs	12.0
Fat meat	5.0 to 12.0
Milk	3.0 to 4.0
Cheese	8.0 to 30.0
Vegetables	0 to 3.0
Nuts	53.0 to 66.0

All animal fats show a remarkable uniformity in elementary composition, containing on an average 76.5 per cent. C, 11.9 per cent. H, and 11.6 per cent. O. The chemical composition of fats indicates the importance of these principles as heat-producing agents. In the carbohydrates and other allied principles, the hydrogen and oxygen are present in such proportion as to form water (starch $C_6H_{10}O_5$), while in the fats, as in tripalmitin ($C_{51}H_{98}O_6$), only twelve atoms out of ninety-eight have their combining equivalent of oxygen contained in the compound, and hence the remaining hydrogen atoms, as well as all of the carbon, are free for oxidation. And since the quantity of heat produced is dependent upon the amount of chemical action or oxidation, it follows "that a given quantity of fat will have the power of appropriating about 2.4 times as much oxygen as the same quantity of starch, or, in other words, will develop about 2.4 times as much heat in the process of oxidation, and hence has about 2.4 times as much value as a heat-producing agent" (Pavy). But while the fats are especially important for the production of heat, and for forming the basis of adipose tissue, they are likewise essential for tissue development generally. The great importance of fat in food and of that deposited in the body is to be found in the aid which it furnishes to the hungry organism in developing its wasted tissue. A purely proteid diet for a person poor in fat necessitates a large amount of the former to sustain the weight of the body, indeed more than the intestines are capable of absorbing. But a mixture of fat with the proteid matter diminishes both the amount of circulating albumin in the body and the proteid metabolism. The proteid food is needed to sustain the bodily wants, and at the same time to prevent the loss of fat. Still, it is not possible to convert a poor body into a body rich in fat and proteid material by a simple albuminous diet; fats or carbohydrates are needed, admixture of which diminishes the work of the organism. The energy of the active cells of the body is then only in part used for the decomposition of albumin, the remaining energy being applied to the decomposition of fatty matter. This is well illustrated by the increased metabolism of fatty matter during muscular exertion. In the words of Voit, "muscular work renders the cells capable of decomposing more material, and, after the use of the disposable albumin, the fat is brought into requisition. Thus nothing is of greater influence upon fat metamorphosis than work." (See *Nutrition*.)

The carbohydrates, being especially found in the vegetable kingdom, belong essentially to a vegetable diet. A few, however, occur in animal food, as glycogen and sugar in the liver, lactose in milk, and the sugar present in small quantities in muscle tissue. In composition, the carbohydrates are all alike in containing hydrogen and oxygen in such proportion as to form water. They may be divided into three main groups, viz.: monosaccharides, including such sugars as dextrose or glucose, which have the formula $C_6H_{12}O_6$; disaccharides, including such bodies as cane sugar, having the formula $C_{12}H_{22}O_{11}$, which break down into two molecules of a monosaccharide; and polysaccharides, as starch and dextrins, having the formula $(C_6H_{10}O_5)_n$. As a class they constitute very easily decomposable material, readily breaking down into carbonic acid and water, and as food stuffs they are especially prominent in causing an accumulation of glycogen in the liver. They are, moreover, without doubt, the source, in part, of the fat in the body. Sugar or starch is always present in fattening foods, and although it is doubtful whether the fat is formed directly from the carbohydrates, still the association of fat and glycogen in the hepatic cells, and the fact that the former is increased by such diets as tend to increase the latter, would naturally suggest a connection between carbohydrates and the production of fat. (For a discussion of this question see *Nutrition*.) Carbohydrates, like the fats, tend to diminish proteid decomposition, and even more decidedly; and as they are likewise able to prevent the withdrawal of fat from the body (according to Voit 175 parts of carbohydrates accomplish as much as 100 parts of fat), it is evident that they possess the power, in a high degree, of taking the rôle of the fats. Moreover, while the carbohydrates are being oxidized, the fat formed from albumin is spared, and Voit [14] considers that in both carnivorous and herbivorous animals the main action of carbohydrate food (so far as its connection with fat is concerned) is to protect the fat already formed, and that in no case does the fat itself have its origin in the carbohydrates, but in the carbon surplus of proteid food (see *Nutrition*). Carbohydrates differ from fats in that they contain, weight for weight, less potential energy than the latter. They differ likewise in being more easily digestible.

Under the head of nitrogenous principles, those classified as proteids or albuminous bodies are by far the most important. Of less importance dietetically are the so-called albuminoids or gelatinous principles, and of still less value are the various nitrogenous extractives, so conspicuous in many foods of animal origin.

The proteid or albuminous and gelatinous principles are all very much alike in general composition, showing, however, some decided differences in their content of nitrogen. Most of the proteid bodies occur in solid form, in both the animal and the vegetable kingdom, though a few are to be found dissolved in the fluids of the organism. Voit [15] has estimated from analyses by Bischoff that in a fully developed human body weighing 68.65 kgm. (151.3 pounds) there would be contained, when dry (at 100° C.), 22.4 per cent. of albuminous matter, and 14.8 per cent. of collagenous tissue. The excretory products of animal organisms contain such a large percentage of nitrogen, it is evident that the nitrogenous principles must play an important part in supplying the needs of the body. Of these the albuminous principles are the most important, and for man and animals albumin, in its various forms, constitutes a vital food stuff, without which life cannot be long sustained. As the content of albuminous or proteid matter in the body is large, and as all the active cells of the body are protoplasmic, it follows that albumin must be supplied in considerable quantity to take the place of that used up in the ordinary processes of life. It is, however, widely distributed through both the animal and vegetable kingdoms; notably in the casein of milk, egg albumen, and myosin of muscle in the animal kingdom, and in the coagulable albumin, vegetable casein, legumin, and conglutin of the legumins, and gluten of wheat and rice, etc., in the vegetable kingdom. The albuminous principles, moreover, in view of their containing all of the organic elements necessary to life, are capable, when used in conjunction with the inorganic principles, of supplying alone all the needs of the body; still such a diet would not be an economical one for the system, owing to the large amount of proteid matter which the system would be obliged to work over, together with the subsequent removal of the nitrogen, in order to obtain the requisite amount of carbon. This is easily seen from the composition of pure egg albumin with its 52 per cent. of carbon, when compared with a fat, as tripalmitin with 76 per cent. of carbon, or with a carbohydrate as saccharose with 42 per cent. of carbon and 51 per cent. of oxygen. It is evident, from these figures, that a judicious mixture of an albuminous food stuff with a carbohydrate or fatty food stuff would give a food containing the re-

quired carbon and nitrogen, assimilable with less expense to the body. Liebig's theory, that nitrogenous food is used wholly in building up albuminous tissues, as the muscle and other forms of protoplasm, is now known to be incorrect, and that in reality proteid food stuffs may not only be utilized in the construction and repair of muscular tissue, but may likewise give rise to the storing up of fat. In fact, in the decomposition of proteid matter within the body into the ultimate product, urea, which is excreted, there results a complementary hydrocarbonaceous residue, which can be utilized apparently for the production of heat or other forms of energy. At the same time, the chemically distinct oleaginous and saccharine principles which are together especially concerned, either directly or indirectly, in the production of heat, are likewise of use in the production of other forms of energy, and thus any classification of the alimentary principles based on the physiological grounds originally advanced by Liebig is wholly untenable. It is to be remembered that according to the law of the conservation of energy, the sole cause of animal heat is a chemical process in which food substances are oxidized. The chemical energy of the ingested food manifests itself mainly as heat and motion, and there is no good ground for assuming that the oxidation of proteid may not give rise to heat, as well as the oxidation of fat, etc. Hence, to a certain extent, the two groups of nitrogenous and non-nitrogenous alimentary principles are qualitatively alike, in that both may be concerned in the development of heat and the storing up of fat, although the non-nitrogenous are not distinctly provocative of metabolism. Further, there is no reason why the energy of muscular contraction may not come, in some measure at least, from the decomposition of nitrogenous matter as well as from the oxidation of non-nitrogenous matter. The nitrogenous principles are, however, indispensable to the growth of the tissues of the body, and are likewise indispensable in the production of the nitrogenized enzymes, on the presence of which the digestive juices of the body depend for their special action.

Collagenous tissue, comprising the gelatinous principles (organic basis of bone, cartilage, tendons, and connective tissue), cannot supply the place of the albuminous principles; still, Voit[16] has found that nitrogenous equilibrium is established at a lower level of proteid food when gelatin is added, and Forster[17] apparently considers that in the metabolism of gelatin it rapidly splits up into a urea and a fat moiety, but is unable to imitate the other function of proteid matter, or to take part in the formation of living protoplasm. (For nitrogenous metabolism see *Nutrition*.)

There are a number of crystalline nitrogenous substances, amido-acids and nitrogenous bases, occurring in both the animal and vegetable kingdoms, which are present in greater or less quantity in food, such as creatin and other like proteid decomposition products, contained, for example in some quantity, in Liebig's *extractum carnis;* also the vegetable alkaloids. None of these, however, are of any great value as food; the majority of them pass quickly out of the body, but little if any altered, although one or two, as asparagin,[18] are said to diminish slightly proteid metabolism. The more highly complex lecithin, present in the yolk of the egg, in the brain, etc., may possibly be placed among the true foods, though no direct experiments have been tried to demonstrate its action. It is not improbable, however, that the various amido-acids and nitrogenous bases which are so abundant in animal tissues do have some indirect value as alimentary substances, though they contain little potential energy, and we may reasonably consider that these various nitrogenous extractives have some power, possibly, in influencing the rate of metabolism or in modifying other nutritional processes. The main action of the alkaloidal substances, as the caffeine of coffee, is that of a stimulant, acting especially upon the fatigued nervous system, though many of the common alkaloidal infusions made from roots, leaves, and berries may be somewhat nutritious from the albuminous and fatty matters which they contain, as is the case with cocoa.

The drinks commonly used as food may be divided, aside from water, into the alcoholic, acidulated, saccharine, gaseous, and infusions of various substances, such as tea. The alcoholic drinks contain from forty to sixty per cent. of alcohol, as in rum, brandy, and whiskey, to from two to ten per cent., as in beer and light wines. Malt liquors contain, perhaps, the largest number of constituents, among others there being sugar, dextrin, gluten, and various substances from the hops. The exact value of alcohol as a food, broadly considered, is uncertain. Recent experiments, carefully made on man,[19] however, clearly show that when moderate amounts of alcohol are ingested, the alcohol is burned up in the body—*i.e.*, oxidized like any non-nitrogenous food. The potential energy of the alcohol is transformed into kinetic energy, and consequently alcohol is to be considered as having some food value. It may, therefore, be classified with the non-nitrogenous foods. Further, as a non-nitrogenous food, alcohol may replace an isodynamic amount of fat or carbohydrate in the diet without change in the balance of income and outgo. Alcohol serves to protect body protein and fat from oxidation; *i.e.*, like a typical non-proteid food it diminishes the oxidation of tissue proteid by being itself oxidized. These facts, however, do not imply that alcohol is necessarily a desirable food or that it is physiologically economical. It is to be remembered that, prior to its oxidation in the body, alcohol may produce deleterious effects of various kinds, more than counterbalancing any gain which may result from it oxidation. It may likewise give rise to changes, either directly or indirectly, in the various metabolic processes of the body, which must of necessity influence more or less its value as a food. Alcohol has a direct and an indirect influence upon the secretion of gastric juice.[20] In this direction it acts as a stimulant. It likewise stimulates the secretion of saliva.[21]

Food, as eaten by man and animals, is a natural mixture of the various alimentary principles described. Seldom are the isolated principles eaten by themselves, other than in the case of sugar and salt, or pure fat. It is the function of digestion to separate the individual principles from this natural mixture, by which means they are separately absorbed. The behavior of animal and vegetable food is quite different in the alimentary canal, which difference is dependent more upon the quality of dry substance contained in the latter food than upon its quantity. Vegetable food yields a much larger percentage of indigestible residue, and is in itself much less easily digestible, owing to the fact that it is more or less enclosed in the difficultly soluble cellulose, while animal food is free. Moreover, vegetable food, as a rule, is less easily absorbed, and, as it contains usually a less percentage of nitrogen, a much larger quantity is needed to furnish a certain amount of this element than in the case of animal food. Again, the large quantities of starch contained in a vegetable diet tend to produce an acid fermentation in the small intestines, with formation of butyric acid, together with marsh gas and hydrogen, which causes the frequent intestinal excretions of herbivorous animals.

In a determination of the food value of a given food stuff, or of a given diet composed of a mixture of food stuffs, it is necessary to ascertain its chemical composition with special reference to the content of proteid, fat, carbohydrate, and inorganic salts; its caloric or heat value; and lastly its digestibility or availability. In an ordinary mixed diet, proteid matter is usually present in the proportion of one part to about five parts of non-proteid matter—*i.e.*, fats and carbohydrates. The proportion of fat to carbohydrate is usually exceedingly variable, ranging anywhere from one part of fat to from five to twelve parts of carbohydrate. While these statements are to be accepted as a general expression of the ordinary proportion of the three primary varieties of food stuffs contained in an average diet, it is to be remembered that the

element of cost or the ease of procuring frequently determines the relative amount of the three classes of food stuffs in the daily diet. Thus, in countries where meat is plentiful, as in South America, proteid food is consumed in much larger proportion than above, whereas in some Asiatic countries, the prevalence of rice, cereals, and fruits leads to a daily diet in which non-proteid foods are especially conspicuous, and the proportion of proteid is reduced to the minimum necessary for life. Further, for similar reasons, the ratio of fat to carbohydrate undergoes wide variation among different races or in different countries. Thus, in the far north, fat (animal) constitutes the greater proportion of the non-proteid part of the diet, while in countries where cereals abound, carbohydrates, mainly in the form of starch, make up the greater portion of the non-nitrogenous food.

For the ordinary purposes of food analysis, the amount of proteid present is usually ascertained by determining the content of nitrogen, and multiplying this figure by the empirical factor 6.25, on the assumption that proteids contain on an average 16 per cent. of nitrogen. In recognition of the fact that the value so obtained is not always an accurate measure of the amount of true proteid present, the word "*protein*" is employed as an arbitrary term to designate a group assumed to include all the nitrogenous matter of the food except the nitrogenous fats. True proteids contain 15 to 17 per cent. of nitrogen and 50 to 54 per cent. of carbon. It is very difficult, however, to determine accurately the amount of true proteid in a mixture, and so chemists are practically forced to rely upon the content of nitrogen as a measure of the amount of proteid present. The above variation in the percentage of nitrogen in different proteids, however, introduces a possible error when the nitrogen content is multiplied by 6.25. This error is probably less, however, than that which comes from the fact that in some food stuffs, as in meat for example, there is a certain amount of nitrogen in the form of amido-acids, etc. Still, even here the error is probably not very great. Thus, beef entirely freed from fat contains, when dried, 49.6 per cent. of carbon, 15.3 per cent. of nitrogen, and 5.2 per cent. of ash.[22] While protein is thus seen to be not strictly equivalent to proteid, yet the content of so-called protein gives, as a rule, a fair measure of the amount of true proteid present. In special cases, however, it is necessary to make use of more elaborate methods of analysis, and to differentiate between the nitrogen of proteid and the nitrogen of amids and amido-acids, etc.

Under the head of fats is included the total ether extract of the food. This is ordinarily made up of neutral fats, but free fatty acids are sometimes present, likewise such phosphorized fats as lecithin and protagon, and also bodies like cholesterin and pigments.

Carbohydrates are usually determined by difference, after the ash and water have been estimated, although frequently starch, sugar, and cellulose are determined separately by direct analysis.

Equally important with chemical composition is the determination of the heat value of food stuffs. This is done by multiplying the number of grams of proteid, fat, or carbohydrate by a number, ascertained by direct experiment, representing the amount of heat produced by the oxidation of 1 gm. of the fat, carbohydrate, or proteid, to water and carbonic acid and to urea. Taking the calorimetric observations of Rubner as a standard, it is found that 1 gm. of proteid on an average, when oxidized to urea, yields 4,124 calories or gram degrees of heat (small calories), or 4.1 kgm. degrees (large calories). Similarly 1 gm. of fat, oxidized to carbonic acid and water, yields 9,321 gm. degrees of heat (small calories), or 9.3 kgm. degrees (large calories), while 1 gm. of carbohydrate, as starch, yields 4,116 small calories, or 4.1 kgm. degrees of heat.

The following table gives the percentage composition of a few common foods, together with the heat values expressed in the form of kilogram degrees of heat (large calories) per pound.

	Water, per cent.	Protein, per cent.	Fat, per cent.	Carbohydrate, per cent.	Ash, per cent.	Heat value per pound, calories.
Lean beef, fresh loin	58.2	17.1	11.1	....	0.9	785
Beef, loin, very fat	44.9	16.0	29.1	....	0.8	1,525
Canned boiled beef	51.8	25.5	22.5	....	1.3	1,425
Lean breast of veal, fresh	53.3	16.1	4.3	....	0.9	480
Salmon, fresh	40.9	15.3	8.9	....	0.9	600
Codfish, fresh, steaks	72.4	17.0	0.5	....	1.0	335
Oysters, solid	88.3	6.0	1.3	3.3	1.1	230
Hen's eggs, uncooked	73.7	13.4	10.5	....	1.0	720
Butter	11.0	1.0	85.0	....	3.0	3,605
Cheese, American, pale	31.6	28.8	35.9	....	3.4	2,055
Milk	87.0	3.3	4.0	5.0	0.7	325
Hominy, uncooked	11.8	8.3	0.6	79.0	0.3	1,650
Oatmeal "	7.3	16.1	7.2	67.5	1.9	1,860
Wheat flour, entire wheat	11.4	13.8	1.9	71.9	1.0	1,675
White bread, Vienna	34.2	9.4	1.2	54.1	1.1	1,230
Lima beans, fresh	68.5	7.1	0.7	22.0	1.7	570
Fresh beets	87.5	1.6	0.1	9.7	1.1	215
Potatoes, raw	78.3	2.2	0.1	18.4	1.0	384
Sweet potatoes, raw	69.0	1.8	0.7	27.4	1.1	570
Green peas	74.6	7.0	0.5	16.9	1.0	465
Apples	84.6	0.4	0.5	14.2	0.3	290
Bananas, yellow	75.3	1.3	0.6	22.0	0.8	460
Oranges	86.9	0.8	0.2	11.6	0.5	240
Strawberries	90.4	1.0	0.6	7.4	0.6	180

Taken from Atwater and Bryant, Bulletin No. 28, Revised. United States Department of Agriculture.

As to the amount of food required by an adult during twenty-four hours, much depends upon the condition of the body, and especially upon the amount of muscular work being done. Voit, in Germany, has given for a man of 150 pounds body weight, doing ten hours of muscular work, the following diet as requisite:

105 gm.	assimilated proteid	× 4.1 =	430	large calories.
56 "	fat	× 9.3 =	520	" "
500 "	carbohydrate	× 4.1 =	2,050	" "
			3,000	" "

Atwater,[23] in this country, from a large number of observations, considers a somewhat more liberal allowance of proteid desirable, and a little larger heat value for a man doing severe muscular labor; say 125 gm. proteid and a total heat value of 3,500 large calories. Laying aside minor points of variation, it is safe to assume that a healthy workingman, of average body weight, requires in his daily diet at least 100 gm. of pure proteid, together with sufficient fat and carbohydrate to give a heat value of 3,000 large calories. No doubt, a man can maintain himself in perfect health on a somewhat smaller allowance of proteid, but in order to do this he must increase very greatly the amount of non-proteid food taken, especially carbohydrates.

Taking the above diet of Voit's, and assuming that in order to obtain the 105 gm. of assimilable proteid 118 gm. of proteid food would be required, we find that this means a daily consumption of 18.03 gm. of nitrogen and at least 328 gm. of carbon. Further, since the 118 gm. of albumin contain but 63 gm. of carbon, it is plain that there would be required 265 gm. of carbon, in the form of fats or carbohydrates.[24] The following table gives the number of grams of several common foods necessary to furnish the daily requisite of carbon and nitrogen:

For 18.3 Gm. Nitrogen.	Gm.	For 328 Gm. Carbon.	Gm.
Lean meat	538	Lard	459
Wheat flour	796	Corn	801
Eggs (18)	905	Wheat flour	821
Corn	989	Rice	899
Rice	1,868	Eggs (43)	2,231
Milk	2,905	Lean meat	2,620
Potatoes	4,575	Potatoes	3,124
Lard	4,796	Milk	4,652

It is thus evident that no one of these substances is in itself a proper food. Lean meat, for example, must have added to it fat or carbohydrate, or both; while potatoes,

as an example of a carbonaceous food, require an admixture of nitrogenous matter. Hence a judicious mixture of all the alimentary principles from both the animal and vegetable kingdoms constitutes the food best adapted to the wants of mankind. Finally, emphasis must be laid upon the great difference in heat value between fats on the one hand, and proteids and carbohydrates on the other; fats having per gram a heat value more than twice that of proteids or carbohydrates.

R. H. Chittenden.

[1] Wurtz: Chimie biologique, chapters i., ii., 1884.
[2] Hoppe-Seyler: Physiologische Chemie, p. 28.
[3] Hermann's Handbuch der Physiologie, vi., 347.
[4] Philosophical Transactions, 2, 494.
[5] Zeitschrift für Biologie, ix., 387.
[6] Aronstein: Pflüger's Archiv für Physiologie, viii., p. 75. Alex. Schmidt: Pflüger's Archiv, xi., p. 1.
[7] Zeitschrift für Biologie, vol. ix., 1873.
[8] Weiske: Zeitschrift für Biologie, vol. vii., pp. 179 and 333.
[9] Forster: Zeitschrift für Biologie, vol. xii., p. 464.
[10] Comptes Rendus, 1872, 64, p. 1353.
[11] Compare Homburger: Zeitschrift für physiolog. Chem., vol. ii., 191.
[12] Bunge: Zeitschrift physiol. Chem., ix., p. 49.
[13] Bunge: Lehrbuch d. physiol. u. pathol. Chem., 1889, p. 100.
[14] Hermann's Handbuch der Physiologie, vi., 260.
[15] Ibid., vi., 388.
[16] Zeitschrift für Biologie, viii., 297.
[17] Text-Book of Physiology, p. 467.
[18] Zeitschrift für Biologie, xv., 261.
[19] Atwater and Benedict: Bulletin 69, United States Department of Agriculture.
[20] Chittenden, Mendel, and Jackson: Amer. Journ. Physiol., i., p. 164.
[21] Chittenden and Richards: Amer. Journ. Physiol., i., p. 471.
[22] Argutinsky: Pflüger's Archiv f. Physiol., iv., p. 345
[23] See Atwater and Woods: Bulletin No. 46, United States Department of Agriculture, p. 63.
[24] Voit: Hermann's Handbuch der Physiologie, vi., 497.

ALIMENTARY TRACT.—Development.—The alimentary tract arises from the inner germ layer, reinforced by the visceral layer of the middle germ layer. The inner germ layer furnishes the epithelium of the entire alimentary tract and its accessory organs, the lungs, liver, pancreas, etc. The visceral layer of the middle germ layer, on the other hand, gives origin to all the muscles and connective-tissue layers, and also to the mesentery and omentum. By a process of folding there is gradually formed a tube which at first is broadly in contact with the dorsal wall of the embryo along its entire length immediately ventrad to the notochord. In this tube we can distinguish three divisions, which have received the names of fore, mid, and hind gut. Neither the fore gut nor the hind gut opens to the exterior at first; they end blindly. During the earlier stages of development the mid gut is connected with the yolk sac (Fig. 69), by a wide communication, but as development progresses this communication becomes more and more constricted. This constriction is brought about by

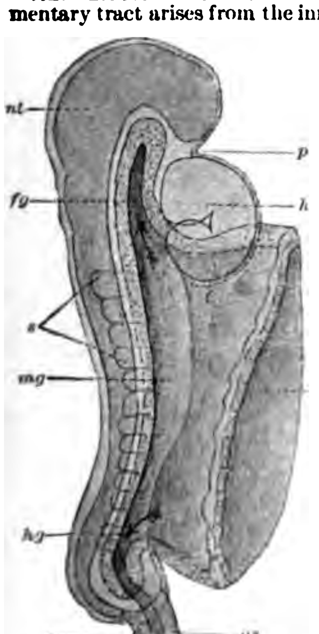

Fig. 69.—Human Embryo, 2.5 Mm. Long. × 30. (After Kollman.) The yolk sac is cut away. The rudiment of the primitive intestines can be seen extending through the embryo. *as*, Allantois stalk; *c*, epithelial tube within the allantois stalk; *fg*, fore gut; *h*, heart; *hg*, hind gut; *mg*, mid gut; *nt*, neural tube; *p*, mouth pit; *s*, somites; *ys*, yolk sac.

the growth caudad, on the one hand, of the fold which gave rise to the fore gut, and on the other hand by the growth cephalad of the fold which formed the hind gut. By this growth in both directions the previously wide

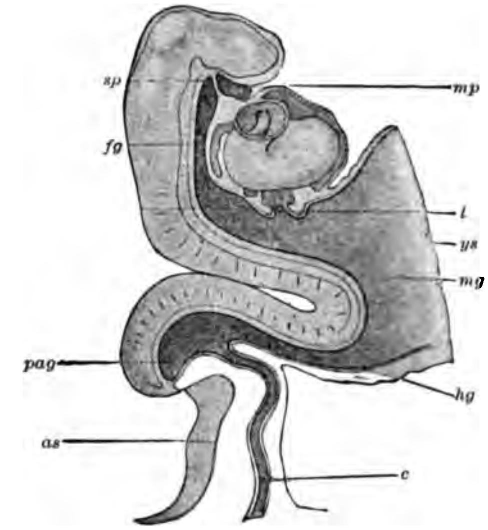

Fig. 70.—Human Embryo, 4.10 Mm. Long. (After His.) *as*, Allantois stalk; *c*, epithelial tube within the allantois stalk; *fg*, fore gut; *hg*, hind gut; *l*, rudiment of the liver; *mg*, mid gut; *mp*, mouth pit; *pag*, post-anal gut; *sp*, Seessel's pocket; *ys*, yolk sac.

communication of the mid gut with the yolk sac becomes smaller and smaller, until finally there remains only a narrow communication between the mid gut and yolk sac—the vitelline duct or *ductus omphalo-entericus*.

On the ventral side of the fore gut the heart is situated, while from the hind gut a diverticulum grows out which

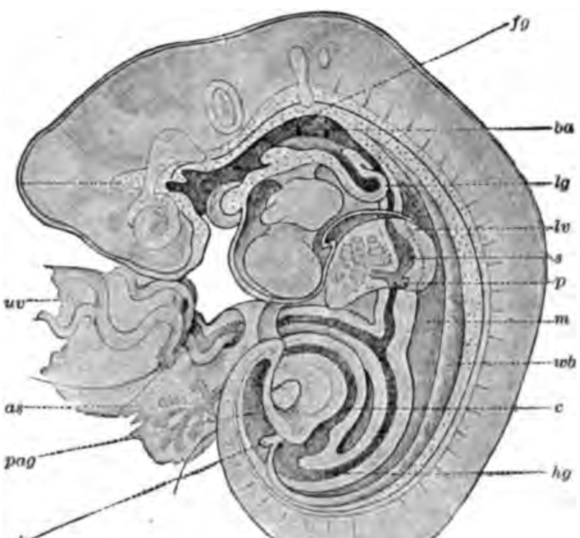

Fig. 71.—Human Embryo, 5 Mm. Long. Sagittal section of a reconstruction. × 15. (After His.) *as*, Allantois stalk; *ba*, branchial arches; *c*, allantois canal; *fg*, fore gut; *hg*, hind gut; *k*, kidney; *lg*, lung; *lv*, liver; *m*, mesentery; *p*, pancreas; *pag*, post-anal gut; *s*, stomach; *uv*, umbilical vesicle; *wb*, Wolffian body.

forms a thick-walled stalk. This stalk is known as the allantoic stalk, or the *Bauchstiel* of His. In man and other primates this diverticulum always remains narrow, but in the lower vertebrates it forms a free vesicle.

Eventually, by the bending ventrally of the fused outer germ layer and parietal layer of the middle germ layer on each side, the vitelline duct and allantoic stalk become

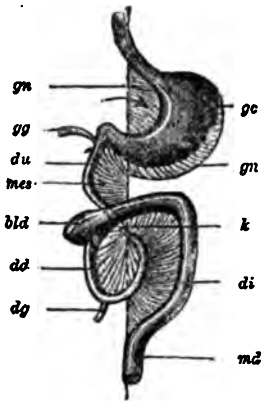

FIG. 72.

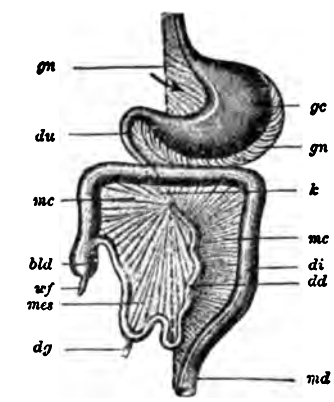

FIG. 73.

FIGS. 72 and 73.—Diagrams of the Development of the Human Alimentary Canal and Its Mesentery. Fig. 72, earlier, Fig. 73, later stage. (After Hertwig.) *gn*, Greater omentum, which is developed from the mesogastrium. The arrow indicates the entrance to the omentum (bursa omentalis); *gc*, greater curvature of the stomach; *gg*, ductus choledochus; *du*, duodenum; *mes*, mesenterium; *mc*, mesocolon; *dd*, small intestine; *di*, large intestine (colon); *md*, rectum; *dg*, vitelline duct; *bld*, cæcum; *wf*, appendix vermiformis; *k*, place where the loops of the intestines cross each other. The colon with its mesocolon crosses the duodenum.

approximated, and there is then formed the umbilical cord, which contains not only the above-mentioned structures, but also the umbilical arteries and vein.

In embryos 2 to 3 mm. in length, the alimentary tube is nearly straight, but in embryos of about 4 mm. length there is a remarkable ventral flexure (Fig. 70).

With the wheel-like bending of the body of the embryo, the head and tail approach each other (Fig. 71), and the entire alimentary tract becomes bent together. This bending takes place gradually. The ventral flexure disappears and the embryo becomes straight. With the increase in size of the embryo, the alimentary tube also lengthens, and we can now distinguish anteriorly a pharyngeal portion, while posteriorly to this, and extending as far as the rudiments of the liver and pancreas, is that part of the alimentary tube which gives origin to the œsophagus, stomach, and duodenum. Posteriorly to the rudimentary liver we have that portion of the alimentary tube which gives rise to the jejunum, the ileum, and the different subdivisions of the large intestine. At first this portion shows only a slight anterior convexity near the vitelline duct, but later it gives rise to the very complex arrangement of the small and large intestines. The most posterior portion of all, the hind-gut, gives rise to the rectum and ends blindly by means of the transitory post-anal gut in the tail of the embryo.

Fig. 72 shows the digestive tract of a human embryo 4.2 mm. long. The wide communication between the mid gut and yolk sac is shown; so also is the comparatively straight course of the intestine.

In Fig. 73, taken from an embryo, 7 mm. long, the stomach shows a slight indication of the greater and lesser curvatures, and the general conformation of the stomach can be made out. A loop of the intestine projects ventrally, and the now narrow connection with the yolk sac is shown. The rudiments of the liver and pancreas can be seen arising respectively from the dorsal and ventral sides of the duodenum.

At a somewhat later stage of development (Fig. 74.) the form of the stomach is more clearly shown. The duodenum caudad to the pylorus passes backward until it comes close to the dorsal body wall; it then bends around sharply ventrally and forms a long loop, the convexity of which is directed forward. This loop consists of two nearly parallel arms running near each other. One is directed ventrally and somewhat backward, while the other, which is situated caudad to it, runs dorsally and is again bent near the vertebral column. From this latter bend it passes caudad toward the anus. The convex end of the long loop thus formed extends beyond the body into the umbilical cord, within which there is an excavation for its reception. The vitelline duct, which is now undergoing degenerative changes, is connected with the intestine at the ventral end of the long loop just described. A short distance from the vitelline duct, on the caudal end of the loop, a second evagination can be seen. This latter develops into the cæcum, and therefore indicates the boundary between the large and the small intestine. "In consequence of these first foldings, four regions of the intestine can be distinguished even now. These are more sharply separated later. The short portion running from the stomach to the backbone and provided with a small mesentery becomes the duodenum (Fig. 74, *Du*); the anterior descending arm (*D*), together with the bend in the loop, furnishes the small intestine. The posterior ascending arm is developed into the colon (*C*), and the terminal part, embracing the last bend, into the sigmoid flexure and rectum (*R*). In embryos of the third and following months there occur, in connection with a further increase in length, important changes in the position of the stomach and the intestinal loops. The stomach undergoes a double twisting about two different axes, and thereby early acquires a form and position (Figs. 72 and 73), which correspond approximately to the permanent condition. First, its longitudinal axis, which unites cardia and pylorus and is, in the beginning, parallel with the vertebral column, takes an oblique and finally an almost transverse position in consequence of a rotation around the dorsal ventral axis. By reason of this rotation the

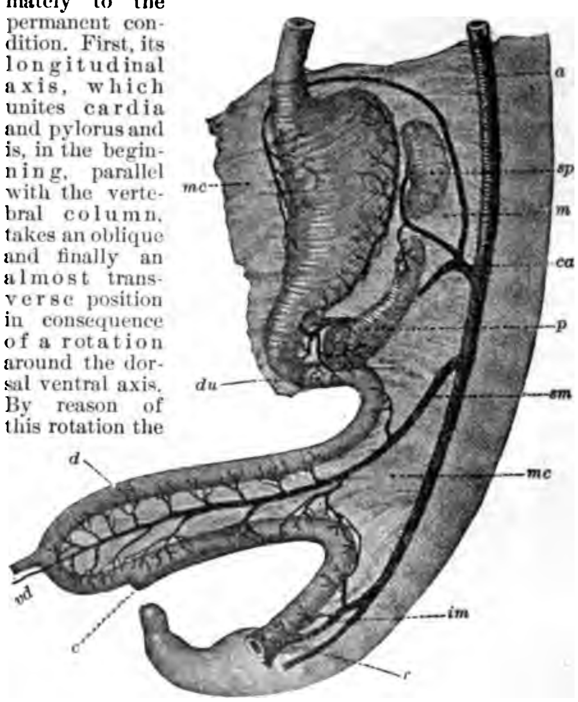

FIG. 74.—Alimentary Canal of a Six-Weeks Human Embryo. (From Kollmann, after Toldt.) *a*, Aorta; *c*, cæcum, on the ascending arm of the intestinal loop; *ca*, cœliaca; *d*, descending arm of the intestinal loop which becomes the small intestine; *du*, duodenum; *im*, mesenterica inferior; *m*, mesogastrium; *mc*, mesogastrium commune; *p*, pancreas; *r*, rectum; *sm*, mesenterica superior; *sp*, spleen; *vd*, vitelline duct.

cardia moves to the left half of the body and downward, but the pylorus more to the right side and somewhat higher. Then at the same time the stomach experiences

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a torsion around its longitudinal axis by which the original left side becomes the front and the right the back. Consequently the greater curvature comes to lie below, the lesser above. The terminal part of the œsophagus is also affected by the torsion. It undergoes a spinal twisting by which this left side becomes the front. . . .

"The intestinal loop with its mesentery passes through a no less fundamental twisting around its place of attachment in the lumbar region than the stomach does. The descending and the ascending arms at first lie side by side, then the latter (which becomes the colon) lays itself obliquely over the former and across the beginning of the small intestine transversely (Fig. 72, *k*).

"Both parts, but especially the small intestine, continue from the end of the second month to increase rapidly in length and to take on a folded condition. Meanwhile the initial part of the colon, called the cæcum, which exhibits even in the third month a curved sickle-shaped vermiform appendage, comes to lie wholly on the right side of the body up under the liver (Fig. 72, *bld*). From here it runs in a transverse direction across the duodenum under the stomach to the region of the spleen; then it bends sharply about and descends to the left pelvic region, where it is continued into the sigmoid flexure and rectum. Therefore there are distinguishable in the colon, even in the third month, the cæcum, the transverse and the descending colon. An ascending colon is still wanting. It is formed in the succeeding months (Fig. 75, *b*) by the gradual sinking down of the cæcum, which was at first under the liver, until in the seventh month it is below the right kidney, and from the eighth month onward descends past the crest of the ilium.

"Meanwhile the cæcum has increased in length, and toward the end of gestation is a rather large appendage at the place of transition from the small to the large intestine. It early exposes the want of uniformity in development (Figs. 72 and 73, *bld*). The terminal part, which often embraces more than half its length, does not keep pace in its growth with the more rapidly enlarging proximal portion. The former is designated as the appendix vermiformis; the latter as the cæcum. At the time of birth the vermiform appendage is still not so sharply differentiated from the cæcum as it is a few years later, when it has been converted into an appendage the size of a goose quill and 6–8 cm. long.

"Within the region embraced by the bends of the large intestine the small intestine, which is derived from the descending arm of the loop, is disposed in more and more numerous folds, owing to its extensive growth in length (Fig. 73)." (Mark.)

The permanent mouth is developed as a pit (stomodæum) on the under surface of the rudimentary head (Fig. 69). This pit extends until it meets the blind end of the fore gut, being separated from it at first by a thin sheet of tissue composed of outer and inner germ layers, and known as the pharyngeal membrane. By the rupture of this membrane, communication is established with the exterior. The formation of the anus is much more complicated than that of the mouth, and is not fully understood as yet. It arises on the ventral side of the body, in front of the neurenteric canal. There is here, as with the mouth, a thinning of the tissue over a limited area, and thus an anal membrane is formed. The place where this thinning of the tissue takes place gives rise externally to a pit (proctodeum), which later becomes connected with the hind gut by the rupture of the above-described anal membrane. The process is therefore similar to that by which the mouth is established.

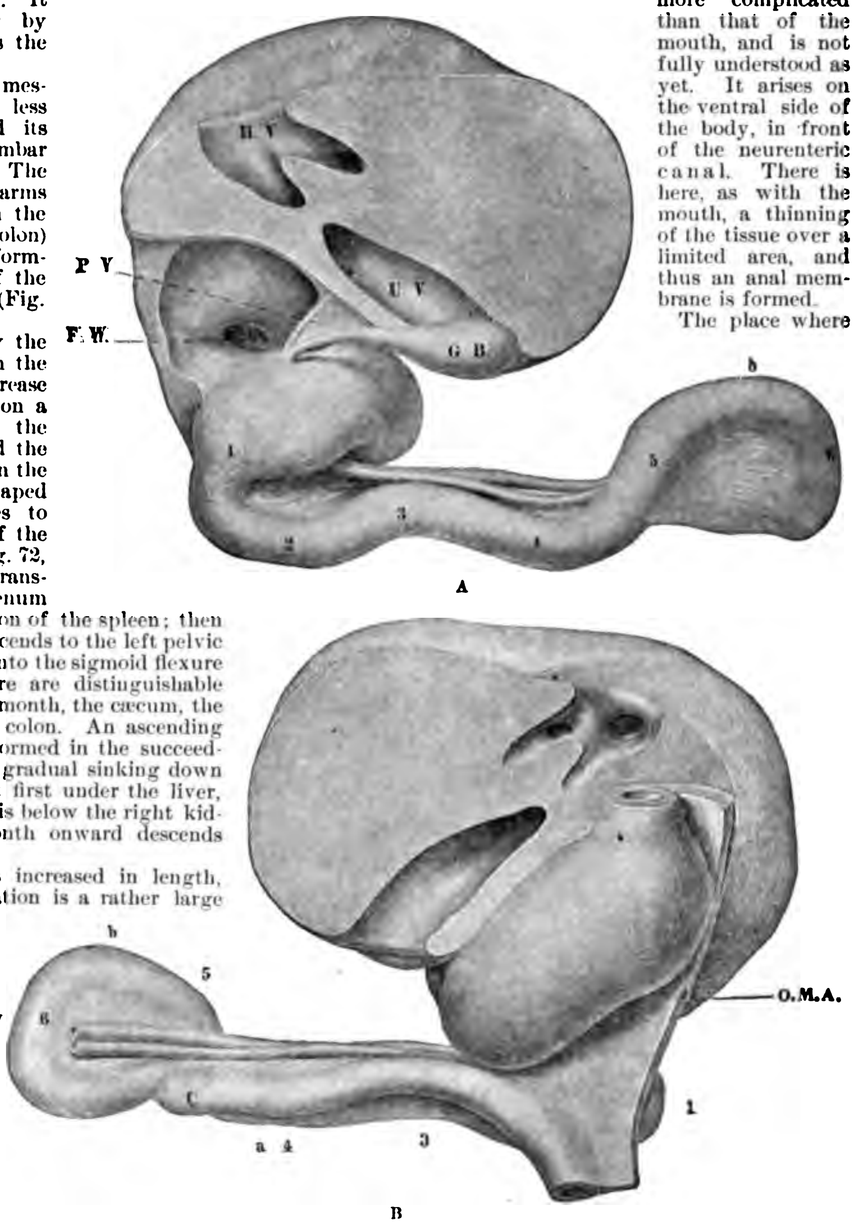

FIG. 75.—Reconstruction of the Liver and Intestine of a Human Embryo of About Five Weeks. A, From the right side; B, from the left side. (After Mall.) × 20. *C*, Cæcum; *F.W.* foramen of Winslow; *G.B.* gall bladder; *H.V.* hepatic veins; *O.M.A.* omphalo-mesenteric artery; *P.V.* portal vein; *U*, place where the omphalo-mesenteric artery and vein cross the intestinal loop; *U.V.* umbilical vein. The numbers 1–6 indicate the commencing intestinal coils. The letters *a* and *b* designate constant points which serve as landmarks in comparing the following series of figures.

Until within a few years the growth and arrangement of the coils of the small intestine were but little understood. The first attempt to find a typical arrangement of the coils was made by Henke, followed by Sernoff, Weinberg, and Mall. In the ensuing de-

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scription I shall follow the latest investigations, those of Mall.

As the intestine grows it pushes itself out of the body cavity into the umbilical cord. This extra-embryonic position of the intestine had already been noticed by

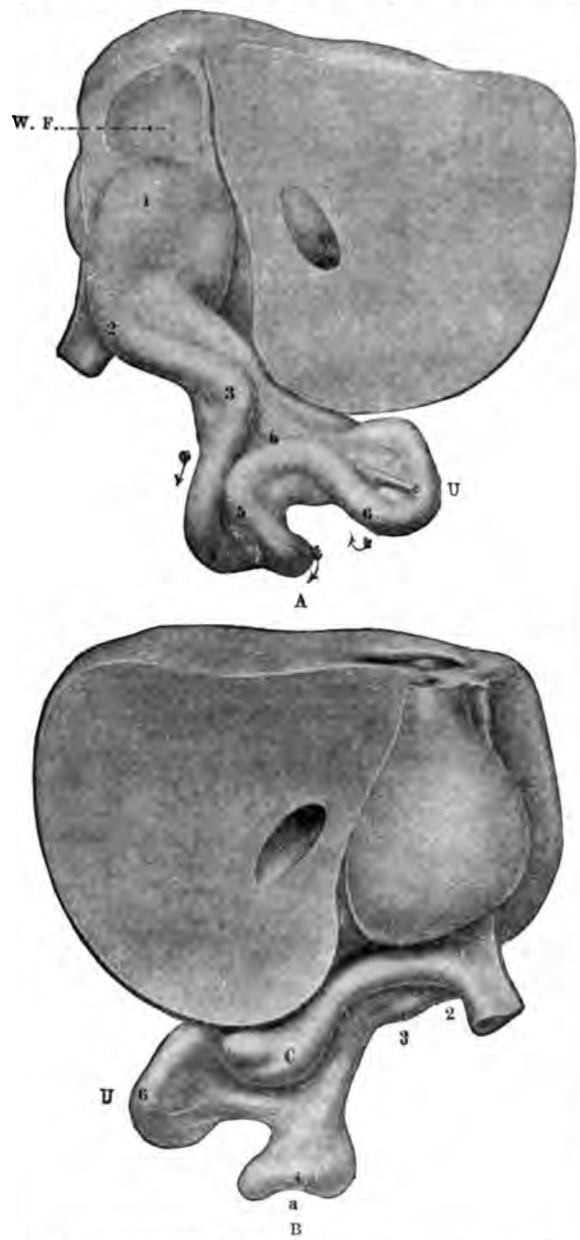

Fig. 76.—Reconstruction of the Liver and Intestine of a Human Embryo, 24 Mm. Vertex-Breech Measurement. (After Mall.) × 10 diameters. A, From the right side; B, from the left side. Letters and numbers as in Fig. 75.

Meckel in 1817. The single loop of which the intestine is composed at this time is shown in the two illustrations forming Fig. 76, which are from a reconstruction of an embryo of about five weeks. It will be noticed that in Mall's figure the relations of the two arms, which make up the intestinal loop, to each other differ from that of Toldt, which is usually given in the text-books. In the figure of Toldt (Fig. 74), there is a ventral and dorsal arm to the loop, while Mall gives a right and left arm. The mesentery between the two lies at right angles to the axis of the embryo in Mall's figures, while in Toldt's it is parallel. His has also described, in his "Anatomie menschlicher Embryonen," similar relations of the intestines. Another point to which Mall calls special attention is that the large intestine lies in the sagittal plane of the embryo, and retains this position until the return of the intestine into the peritoneal cavity.

The right arm of the loop (Fig. 76) has a number of short bends, which have an important relation to the future convolutions of the intestine. The omphalo-mesenteric vessels which lie in the mesentery of the loop in the mid-line serve as a landmark for comparison with older embryos.

The vascular supply of the loop corresponds to that of the adult, since the omphalo-mesenteric artery supplies in

Fig. 77.—Reconstruction of the Liver and Intestine of a Human Embryo of the Same Size as Fig. 76, but Somewhat Older. (After Mall.) × 10 diameters. Viewed from the right side. The growth of each individual coil is easily followed.

the embryo the same portion of the intestine that the superior mesenteric supplies in the adult. The same is true of the large intestine. That part which lies at right angles to the long axis of the body is supplied by the superior mesenteric, and that which lies parallel to the long axis by the inferior mesenteric.

In a somewhat older embryo (Fig. 78), the coils of Figs. 76 and 77 are more sharply defined, and in general it may be said that the coils nearest the cæcum are

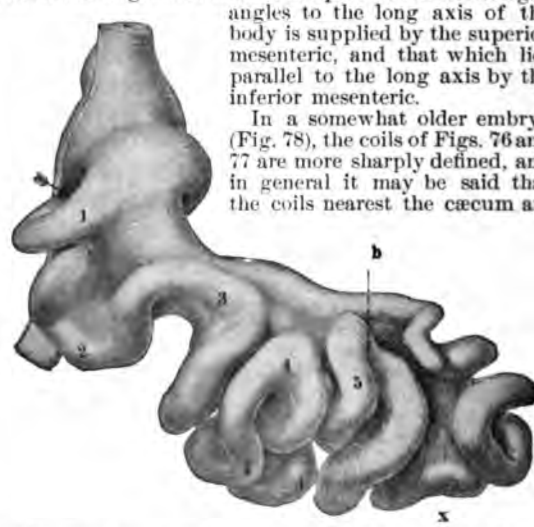

Fig. 78.—Reconstruction of the Stomach and Intestines of a Human Embryo, 28 Mm. Vertex-Breech Measurement. Viewed from the right side. (After Mall.) × 23 diameters.

the strongest developed. The length of the loops has about doubled, while the diameter has increased about

one third. The large size of the liver deserves special notice. I shall refer to this point again.

The next older embryo which Mall figures had a vertex breach measurement of 24 mm. The large intestine occupies the same position; it has increased in length, but not in diameter. A well-defined processus vermiformis is present on the cæcum. A comparison of Figs. 76 and 77 will show the growth of the coils of the intestine. While this growth is rapid, the relations of the coils to one another remain practically the same, and can be followed through successive embryos.

For example, the point *b*, which marks the end of loop 5, occupies in all four embryos (Figs. 76 and 77) the same relation to the cæcum and umbilical vessels. This point seems to be a landmark for determining the loops on the right side of the mesentery, just as *a*, in corresponding views of the left side, is for the intestinal loops on that side of the mesentery (Figs. 75 and 76).

The occasion of the intestine being forced out into the umbilical cord has been previously determined by Mall to be the "great amount of shifting which takes place from the head toward the tail on the ventral side of the embryo during its development." The liver also grows very rapidly and occupies nearly the entire abdominal cavity, thus forcing the intestine into the cœlom of the umbilical cord. That this view is correct, Dexter has demonstrated in his study of the same question in the development of the cat, and I have formed the same opinion in my study of the development of the intestine in the turtle, *C. picta*.

While the forces which compel the intestine to leave the peritoneal cavity and pass into the cœlom of the cord are well established, it is quite difficult to understand why, at a later period, they return into the abdominal cavity. At the time when they leave the abdomen for the cord, the communication between the body cavity and the cœlom of the cord is wide, but at the time of their return into the abdomen it is narrow and offers a seeming impediment to their return.

The return into the body cavity of the intestine is quite rapid, and takes place when the embryo is about 40 mm. long. Up to this time, the lower part of the body has not grown as fast as the upper, but now, owing to its rapid growth, the peritoneal cavity becomes much larger and the intestines are drawn back to fill this place. This seems to be the probable explanation.

While these changes have been taking place in the small intestine, the large intestine from the left flexure of the colon to the rectum has remained quite straight in its course. From the cæcum to this flexure, however, the large intestine has gradually extended itself in a curved direction diagonally across the body cavity from left to right, until the cæcum comes to lie in the right iliac fossa. It is during this change of position that the appendix reaches its full stage of development.

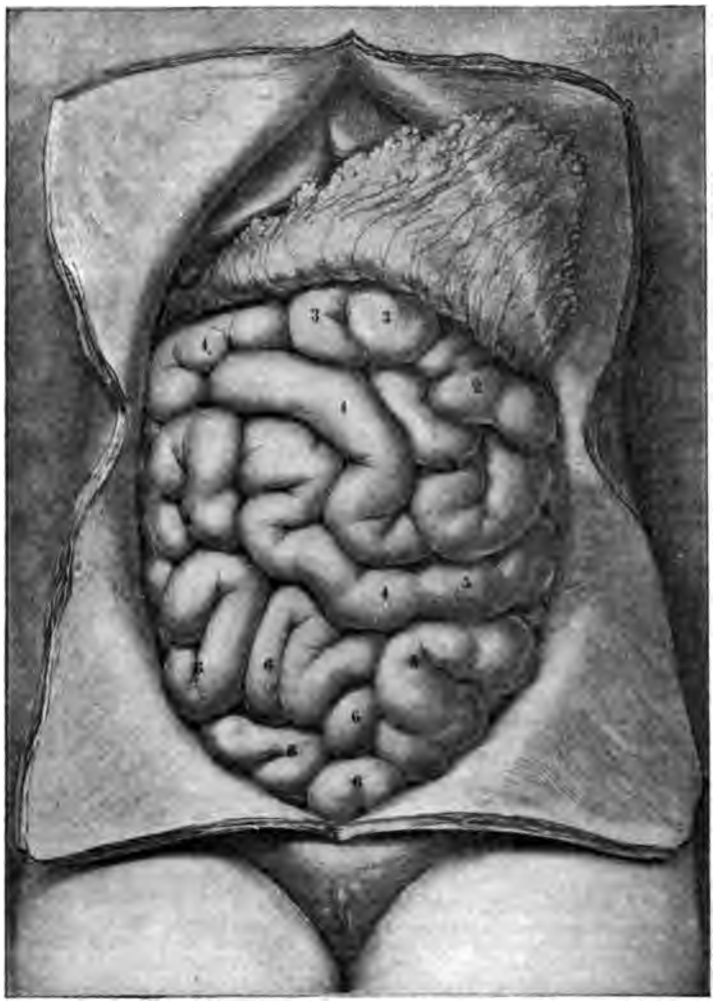

FIG. 79.—This Figure Shows the Position of the Intestine as Found by Mall in 21 of the 41 Bodies Examined by Him. The abdomen was opened by a crucial incision; the great omentum is turned back and to the left. No portion of the large intestine is exposed to view. The figures 2-6 designate the parts of the intestine which are homologous with the coils seen in the preceding figures. The coil 2 is the continuation of the duodenum. (After Mall.)

TOPOGRAPHICAL ANATOMY OF THE INTESTINE.—We have now followed the growth of the intestine, and it remains to describe the position which the coils occupy in the adult. As can be easily inferred, the embryonic condition foreshadows that of the adult.

Mall studied the arrangement of the intestinal coils in the abdomen of forty-one adults. In twenty-one cases the coils were arranged in the same manner. This may be taken as the normal arrangement of the intestine, and the other cases as variations.

In these "normal" cases, the jejunum forms two groups of coils, which occupy the left hypochondriac region. Each of these groups describes more than a complete circle, and both are in contact with the anterior wall of the abdomen (Figs. 79 and 80). The intestine then crosses through the umbilical region to the right side of the body. It then makes a turn and again crosses the median line caudad to the first arm, and forms a loop in the left iliac fossa. From here it passes into the pelvis and the lower portion of the abdomen, between the psoas muscles. Fig. 80 gives the details of the loops as above described.

LARGE INTESTINE.—The large intestine is divided into the *cæcum*, the *ascending*, *transverse*, *descending*, and *sigmoid colon*, and the *rectum*. The various divisions of the colon form a horseshoe-shaped border about the small intestine (Fig. 80).

Cæcum.—The cæcum is situated in the right iliac fossa

and is about 60 mm. in length and 75 mm. in breadth. It includes that part of the large intestine which lies below the entrance of the small intestine, and also its prolongation, the appendix.

The cæcum lies in front of the ilio-psoas muscle, and its relations to the walls of the abdomen and the other divisions of the alimentary tract vary, according as they are distended or collapsed. When the cæcum is somewhat distended and the small intestine nearly empty, it comes into direct contact with the anterior abdominal wall and comes at once into view, together with a portion of the ascending colon, when the abdomen is opened by means of a crucial incision and the flaps drawn back. In this

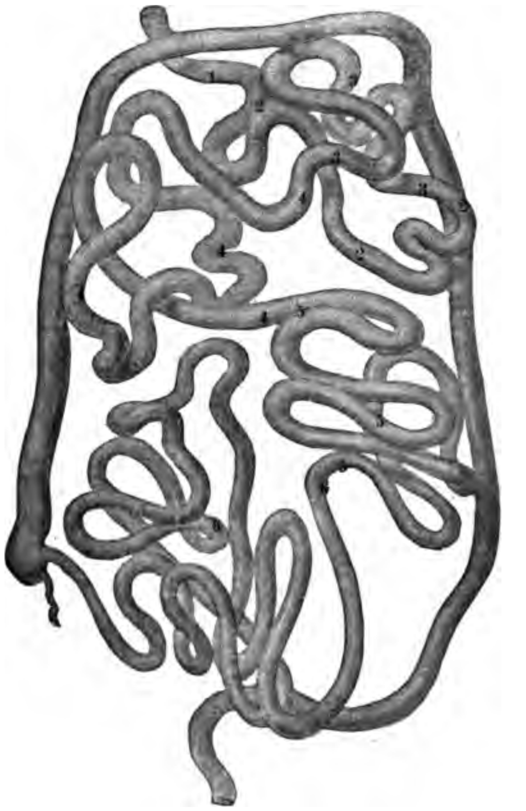

FIG. 80.—The Relation of the Coils of the Small Intestine to One Another and to the Large Intestine. The figures designate, as in the preceding figure, homologous portions of the intestine. The course which this intestine takes is that of the normal type. (After Mall.)

case it lies above the outer half of Poupart's ligament. On the other hand, when the small intestines are distended or when they have been pushed to the right by a distended sigmoid colon, the cæcum is covered by the coils of the small intestine, which are interposed between it and the abdominal wall in front.

Appendix Vermiformis.—The appendix arises from the inner and back part of the cæcum. It varies in size, the extremes being 1 or 2 mm. as the shortest and 23 mm. as the longest. Its average length is 9.2 mm. and its diameter 6 mm. The place where the appendix unites with the cæcum can be found by following any two of the three longitudinal bands of muscle which characterize the large intestine, into the right iliac fossa.

The course which the appendix takes varies greatly. It may be drawn out straight. It may be wound into a spiral. Its position also varies, but it will generally be found passing from behind the cæcum, either upward and to the left behind the ileum and mesentery, in the direction of the spleen, or downward and to the left so as to lie on the brim of the pelvis, or even project into that cavity. Sometimes it is situated entirely behind the cæcum. The appendix is usually hollow throughout its entire extent. The opening into the cæcum is often described as being guarded by a valve. Berry has, however, shown that this valve is inconstant and without any importance.

Ascending Colon.—The ascending colon extends from the cæcum below to the *flexura coli dextra* above. It passes at first obliquely backward to the dorsal wall of the abdomen. It then takes nearly a vertical direction, and in its upper portion bends forward toward the abdominal wall. Its posterior circumference borders, on this median side, upon the psoas muscle. After it has left the right iliac fossa, it lies first upon the quadratus lumborum and then on the lower portion of the right kidney. Laterally, it touches the abdominal wall; above, it is completely covered by the coils of the small intestine. When it is highly distended, it may push the small intestine so far to the left that a small portion is visible on opening the abdomen.

The angle which the ascending colon makes with the transverse colon is quite distinct. In the flexure the large intestine does not pass directly across the abdomen, but bends somewhat toward the anterior wall of the abdomen, on account of the adjoining organs. From the kidney the large intestine must pass toward the ventral side of the abdomen, in order that it may get in front of the duodenum and pancreas.

The Transverse Colon.—In front the flexure is covered by the liver, and below it rests upon the coils of the intestine. In the normal condition, when the abdomen is opened, the transverse colon cannot be seen, being covered by the great omentum (Fig. 79). If one cuts off the omentum or turns it up, the transverse colon is brought into view. In the latter case it appears to run directly from the right to the left. This is, however, a false appearance, due to the fact that the colon is drawn upward out of its normal position. In its normal condition the transverse colon runs in a slight bend, with its convexity below and in front.

The left end of this convexity lies on a higher plane than its right, because the right flexure of the colon is prevented by the liver from rising as high as the left flexure. In front of the transverse colon lies the great omentum, and, since this is a thin membrane, we can say that the transverse colon is in contact with the ventral wall of the abdomen. The left portion of the transverse colon borders upon the great curvature of the stomach in such a manner that the lower convex bend of the intestine nearly corresponds to the line of curvature of the stomach. This close relation between the stomach and the transverse colon makes it often difficult to determine their respective boundaries by percussion.

The left flexure of the colon forms a continuation of the transverse colon. It lies behind the fundus of the stomach, in front of the left kidney, and extends as far as the basal surface of the spleen. The angle which the transverse colon and the descending colon form with each other in this flexure is much more acute than that which is present in the right flexure. Not infrequently the adjoining portions of the two arms of the flexure lie close beside each other. The relation of the transverse colon to the adjoining viscera, and of the arms of the flexure to each other, may be considerably changed by a distended or collapsed condition of the intestines.

Descending Colon.—The descending colon bears much the same relation to the body wall as does the ascending colon. Above, it rests upon the convex border of the left kidney, and then passes slightly toward the median line. It extends below to the left iliac fossa, where it joins the sigmoid colon. It is overlaid by the small intestine, and in its normal condition is not exposed to view when the abdomen is opened.

Sigmoid Colon.—The sigmoid colon occupies a very considerable portion of the iliac fossa. It is connected above with the descending colon, and below it passes over a brim of the pelvis and joins the rectum. The upper portion of the sigmoid colon is usually firmly fixed in the

fossa; but the lower part is quite movable, in consequence of which it may at times form a loop, which hangs down into the true pelvis.

Rectum.—The rectum is the last division of the large intestine, and is situated entirely within the true pelvis. It extends from the sigmoid colon to about the anus. From the brim of the pelvis, where it joins the sigmoid colon, it passes downward, backward, and to the right in order that it may reach the median line. In general it follows from this point the curve of the sacrum and coccyx, and ends in the anal canal. The anterior wall of the rectum is longer and more curved than the posterior. In children the rectum has a straighter course than in adults, and is of a relatively larger size.

Variations.—The remaining twenty cases examined can be divided into five groups. The first group consists of six cases in which loop 4 (Fig. 80) extended to the left side of the body. The remainder of the small intestine occupied the position given above.

The second group also consisted of six cases. In these cases the loop 4 was also on the left side, and in addition the loops 1 and 2 were pushed to the right side of the abdomen; that is, all the upper portion of the jejunum formed coils which were situated on the right side of the abdomen.

In the third group there were five cases. The variation here was occasioned by a supernumerary coil from that portion of the small intestine which is situated in the hypogastric region, extending up into the umbilical and right lumbar regions. Sernoff has also described similar cases.

The fourth group consisted of two cases in which coil 4 was again carried to the left side, and the space which it should occupy was filled by two coils, one of which came from the upper part of the jejunum, while the other came from the lower portion of the ileum.

The fifth and last variation was found but once. Loop 4 was elongated, and its place was occupied by a large loop which came up from that part of the ileum which is situated in the hypogastric region. A similar case has been described by Henke.

It is interesting to note that in four of these five groups, loop 4 takes some part in the variation.

William S. Miller.

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ALIMENTATION, RECTAL.—Rectal alimentation is employed whenever nutrition in the ordinary way (by the mouth) is either impossible or not desirable. This method of alimentation was already used in the Middle Ages and in ancient times. Aetius[1] occasionally mentions such method of feeding. The value of this way of nourishing a patient, however, was believed to be very slight, until extensive experimental researches with reference to absorption of food from the large bowel had been made. These definitely showed that digestion to a great extent can proceed in the colon if the ingested food is suitably prepared. Among the earliest investigators in this direction were Hood[2] and Steinhäuser.[3] Hood observed that a piece of mutton introduced into the rectum and retained, after some time showed evident signs of digestion. Steinhäuser experimented on a patient with a fistula of the ascending colon, and found that pieces of albumen introduced into the fistula could not be discovered in the fæces. Pieces of smoked beef and apples, on the other hand, were found either slightly altered or entirely unchanged in the stool.

Eichhorst[4] stated in 1871 that absorption of albuminates from the bowel is facilitated, if not made possible, by the addition of common table salt. He experimented principally with egg albumen mixed with the yolk and with milk. Some years later, Ewald[5] observed the very interesting fact that raw eggs were much better absorbed from the large intestine than artificially peptonized foods (Kemmerich's peptone).

Filippi[6] experimented on animals by resecting portions of the intestinal canal. He found that after extirpation of seven-eighths of the small intestine in a dog, there was no appreciable decrease in the absorption of foods consisting of albuminates and carbohydrates, while nineteen per cent. of the ingested fat returned with the fæces. This clearly shows that the colon can vicariously do the work of the small intestine. It further demonstrates that albuminates can be absorbed from the large intestine and enter the lacteals without previous peptonization. These remarkable statements have been confirmed by Aldor.[7] This writer experimented principally with milk, and ascribed the coagulation of the milk in the large bowel to the action of bacteria, not to enzymes. He found that after the injection of from ten to fifteen ounces of milk into the bowel, intestinal lavage, performed one to one and a half hours later, showed only minute particles of milk. The spontaneous evacuation resulting thereafter likewise contained but very small portions of coagulated milk.

Aldor, in his paper, arrived at the following conclusions:

1. A quart of milk, injected by means of a fountain syringe into the bowel, produces no pains either during the injection or afterward. No irritation of the intestine follows, and milk is most suitable for a nutritive enema.
2. The coagulation of the milk, which is due to the action of the bacterium coli commune, is rather detrimental to absorption. This coagulation can be prevented, (*a*) by thorough lavage of the bowel before giving the nutritive enema, (*b*) by adding 1 to 1.5 gm. (gr. xvi–xxiv.) of sodium carbonate to one quart of milk.
3. No digestion takes place in the large bowel.
4. Carbohydrates are absorbed in an excellent manner, albuminates in a great measure, and fats but poorly.
5. After an injection of a quart of milk into the bowel, there was never found either albumin or sugar in the urine.

In America the attention of the medical profession was first directed to rectal alimentation by Austin Flint,[8] who read an extensive and important paper on this subject before the New York Academy of Medicine in December, 1877. Flint mentioned a case in which a woman was almost wholly nourished per rectum for five years. After emphasizing the importance of rectal alimentation in instances in which the usual mode of nutrition fails or is impossible, he gives directions as to the mode of employment of the nutritive enemata. From three to six ounces of fluid or semi-fluid foods may be injected at intervals of from three to six hours. He did not deem it necessary to wash out the rectum prior to each administration of the nutritive enema. Flint, as well as Peasley, Fordyce Barker, A. H. Smith,[10] and G. M. Smith,[9] who took part in the discussion of the above paper, had all practised this method of feeding with best results. A. H. Smith mentioned several instances of gastric ulcer in which nutrition had been successfully maintained by

rectal alimentation for from eleven to sixteen and twenty-one days. He was the first who suggested the use of defibrinated blood for this purpose.

Very shortly afterward W. Bodenhamer[11] published an instructive monograph on rectal medication, in which he also laid stress upon the practical value of rectal alimentation as deserving much more frequent application than heretofore.

Stillman,[12] in his paper on rectal alimentation, says: "The clinical fact remains that certain foods, digested or undigested, are taken into the system when thrown into the rectum; that the power of absorption there may be good when the stomach is weak and rebellious; that it is assimilated, for the body gains in flesh and power, and that there may be merely the customary evacuation as an excretory resultant. As far as I am aware, no danger attends feeding by the rectum, when conducted with ordinary care and intelligence on the part of nurses or attendants." In this paper Stillman calls attention to the use of supplementary rectal feeding, *i.e.*, to the use of nutrient enemata while the stomach is yet performing its functions to quite a considerable extent, as, for instance, in chronic gastritis, gastralgia, nausea, etc. He used principally enemata of milk according to the following formula: 5 grains of Fairchild's pancreatic extract and 15 grains of bicarbonate of soda to a pint of milk.

The writer has had extensive experience with rectal alimentation and is fully convinced of its great practical value. The indications for this mode of alimentation may be summarized as follows:

1. In conditions in which the passage of food from the mouth to the stomach or to the small intestine is impeded or made impossible (strictures, benign or malignant, of a high degree of the œsophagus or cardia, spasmodic or paralytic conditions of the œsophagus, pyloric or duodenal stenosis).

2. In ulcer of the stomach accompanied by considerable hemorrhage, or when the usual methods of treatment have failed.

3. Incessant vomiting, no matter to what cause it be due.

4. In all conditions in which absolute rest for the stomach seems to be imperative (intense pains soon after ingestion of food; persistent hyperchlorhydria of a high degree; intense chronic continuous gastro-succorrhœa; pronounced ischochymia).

5. In typhoid fever and other severe lesions of the small intestine necessitating a complete rest of this portion of the bowel.

For how long a period rectal alimentation should be administered depends upon the condition necessitating it. In ulcers and irritating affections of the stomach, rectal alimentation should be administered alone, without any additional nourishment through the mouth, for a period varying from one to two weeks, when the natural mode of nutrition may be cautiously resumed. In cases in which there is an organic obstacle within the œsophagus or at the pylorus preventing the passage of food into the intestine, rectal feeding must be carried on as long as the impediment exists (in operative cases until a few days after the operation has been performed; in inoperable cases, indefinitely). Here, whenever possible, besides the enemata, small quantities of liquid foods may also be given by way of the mouth.

Shortly after operations on the œsophagus, stomach, and small intestine, rectal alimentation must be administered for a period varying from four days to a week or ten days.

Mode of Administration.—Before administering the feeding enema, a cleansing injection (consisting of a quart of water and a teaspoonful of salt) should be given early in the morning, in order thoroughly to evacuate the bowel. One hour later the first rectal alimentation may be administered. The feeding enema is best injected by means of a fountain or Davidson syringe, or a plain hard-rubber piston syringe, and a soft-rubber rectal tube, which is introduced into the anus for a distance of about five to seven inches. The injection should be administered slowly and without much force. After the withdrawal of the tube from the rectum, the patient is told to lie quietly and to endeavor to retain the enema. The quantity of the feeding enema may be from five to ten ounces. From three to five such enemata may be given daily.

The following substances may be used as feeding enemata:

(*a*) The different kinds of peptones and propeptones in the market (Rudisch's or Kemmerich's peptone, somatose, sanose), of which about two to three ounces dissolved in from six to eight ounces of water are to be injected. The different beef juices (Valentine's beef juice, bovinine, Mosquera's beef jelly, etc.) may also be dissolved in water and injected in corresponding quantities.

(*b*) The milk and egg enemata; these are the most commonly used. Their composition is as follows: six to seven ounces of milk, one or two raw eggs well beaten up in it, one teaspoonful of powdered sugar, and one third of a teaspoonful of common table salt.

Pancreatin (one tube of Fairchild's pancreatin) may be added to such an enema, to facilitate its assimilation.

(*c*) Meat pancreas enema. Leube[13] employs enemata consisting of well-chopped meat (five ounces), fresh pancreas (two ounces,) one ounce of fat (butter)—all these ingredients being thoroughly mixed with about six ounces of water.

Instead of always using one and the same nourishing enema, the above combinations may be alternately administered.

In conjunction with these food enemata, injections of water into the bowel are made in order to increase the amount of fluid in the system. These injections of water for absorption are of great importance. Usually saline solutions are employed, in quantities varying from a pint to a quart, which may be given twice a day.

Max Einhorn.

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ALKAKENGI. See *Solanaceæ*.

ALKALIES, ANTACIDS.—These are medicines which are administered for the purpose of correcting acidity. The terms are almost synonymous, but it will be found that the drugs arrange themselves into two groups, according to their solubility, which in a great measure determines their therapeutic uses. In one we have potash, soda, and lithia; in the other lime, magnesia, cerium. The former are generally employed as alkalies, the latter as antacids. Ammonia is intermediate; its character would place it in the first group, but its therapeutic use makes it belong rather to the second.

Potash, soda, and lithia salts are very soluble, and are readily absorbed and as readily excreted; they pass from the system in a very short time. They are normal constituents of the blood, and their presence in increased amount tends to render the plasma more alkaline.

The second group, comprising lime, magnesia, and cerium, are much less soluble, and even their more soluble salts (as the sulphates of magnesia, etc.) are but slowly

absorbed. In consequence their action is almost entirely limited to the digestive tract. Such portions as do enter the circulation act upon the blood in the same manner as do the more soluble alkalies, and are excreted by the same channels. Their power of rendering the blood alkaline is so inferior to that of the more soluble alkalies that they are never selected for this purpose. Many of their soluble salts, as the chlorides, phosphates, and hypophosphites, are only mildly alkaline, and are of value more for the acids in combination than for the alkaline base.

The action of alkalies upon the secretions of the stomach, as formulated by Ringer, has been confirmed by subsequent experience. His view is that the contact of weak alkaline solutions with glands secreting an alkaline fluid causes a lessening of the secretion, while on acid-secreting glands the effect is to cause an increase of the acid secretion. Advantage has been taken of this in gastric disturbances, when there is a deficiency of acid during digestion. The administration of alkalies just before meals has proved most serviceable in relieving this defect. They must be given well diluted and in moderate doses. The bicarbonate of soda or the bicarbonate of potash is generally selected; it is to be given in five-grain doses. Ammonia, in the form of the aromatic spirits, is often combined with some stomachic, as tincture of rhubarb, tincture of cardamons, capsicum, ginger, or peppermint, and in addition a vegetable bitter. This combination has been found to be valuable. In addition to the local effect thus produced upon gastric digestion, a further benefit is derived by the action of alkalies after absorption. They rapidly pass into and improve the blood, and during excretion they cause a general stimulation of all secreting organs. As alkalizers of the blood, they are used in gouty and rheumatic conditions, in lithiasis, and in many disorders of the skin in which there is supposed to be an excess of uric acid or allied acids in the blood. Their purpose is to keep these morbid products in solution until they are carried out of the system. The potassium salts are preferred, as their rapid absorption renders the blood more quickly alkaline, while their equally rapid excretion prevents any accumulation. For immediate action the solution of potash or the bicarbonate salt is selected; but when a prolonged use is required, the citrate, acetate, or tartrate is preferred, as these salts produce less irritating effects upon the stomach. Sodium salts are more slowly absorbed and are less powerful alkalies. The normal alkaline state of the blood is due chiefly to sodium salts, and as they are less depressing than potassium salts, they offer many advantages when a prolonged course of treatment is necessary. In treating rheumatism with the alkalies, they require to be given freely until the urine becomes alkaline, and then they should be reduced, enough being given simply to maintain this reaction. There may be given a drachm and a half of bicarbonate of soda and half a drachm of the acetate of potash every three or four hours, well diluted, for four or five doses; following this, fifteen or twenty grains will usually be sufficient. Lithia is very similar to potash in the rapidity of its absorption and excretion. It has been extolled as superior to the other alkalies, and is now very generally used. Later observations, however, tend to lessen this estimate. It has been shown that its solvent action is not remarkable, and it is probable that its value lies in its diuretic properties. The action of ammonia is very evanescent; it is never employed to replace the other alkalies, as its effect is to increase the acidity of the urine.

The alkalies are excreted rapidly by all the secreting organs. Their effect is most evident on the kidneys, and during excretion they render the urine alkaline. At the same time they augment the watery flow through an increased activity of the renal cells. The secretion of all organs is increased, as is also the secretion of the mucous surfaces.

The action of alkalies upon the blood and tissues is as yet imperfectly understood. We know that they promote tissue change and favor elimination. We also know that they prevent the deposition of uric acid in the tissues. How this is effected is uncertain, but their action depends upon something more than simply rendering the blood alkaline. Until the true cause of gouty and rheumatic affections is discovered, an explanation will be difficult. We seem further from a solution than ever, now that the existence of any excess of uric acid in these attacks is being called in question.

Alkalies are all powerful depressors. Potash and lithia are the most injurious, and soda is the least. They reduce the blood corpuscles and the protoplasmic tissue. In large doses they are cardiac poisons, and their prolonged use in moderate doses causes anæmia, loss of body weight, and loss of muscular power.

The alkalies are also of benefit when applied to the surface of the body. In rheumatism a hot lotion of carbonate of soda with opium often affords relief to the painful joint. In all forms of cutaneous disease accompanied by a troublesome itching, an alkaline wash of carbonate of soda or potash, half a drachm to the pint, is of service, and in eczema during the early stage, with an alkaline watery discharge, the same solution is curative. Burns and scalds may be treated in the same way, the solution being constantly applied. The alkali removes the heat and pain and allays inflammatory action. The bites and stings of insects and the urticaria produced by poisonous plants are also benefited.

The oxides and carbonates of lime and magnesia are the most serviceable salts as antacids, on account of their insolubility. If these drugs are given in small quantities their action may be limited to the stomach; when they are freely administered, their action is continued into the intestines. They neutralize all acids with which they come in contact, and by contact with the mucous surface they exercise a soothing and sedative effect. In addition to neutralizing the local acids, they are of value as antidotes in poisoning by acids, and also in poisoning by vegetable poisons, the alkali precipitating the poisonous alkaloids and retarding their absorption. In the intestine the antacid action is continued, but the ultimate effects of lime and magnesia differ; the former acts as a mild astringent, while the latter becomes converted into the bicarbonate and acts as a laxative.

The soluble alkalies are not so useful as antacids, and are of little service when an effect in the intestines is required. Sodium bicarbonate, however, is a well-known antacid. Its disadvantages are that it tends to generate a large amount of carbonic acid gas, and is stimulating instead of soothing to the mucous surface. The aromatic spirits of ammonia is similar in its action and more rapid. Cerium oxalate and bismuth are both useful antacids, their chief value being due to the local soothing action which they exert upon the mucous membrane. The cerium salt has probably a sedative action on the terminals of the nerves. *Beaumont Small.*

ALKANET.—(*Orcanette.*) The fleshy root of *Alkanna tinctoria* (L.) Tausch. (fam. *Boraginaceæ*), a small perennial herb of Europe and Asia Minor, largely cultivated for its coloring matter. The dried root, a foot or more in length and about a half-inch in thickness, its bark purple red without, deep red within, its wood pinkish white, is sometimes marketed entire, but more frequently as a stringy, shredded, tough mass. Its only value is for coloring purposes, the coloring matter being *alkannin* or *alkanna* red.

Alkannin is a dark, brownish-red, resinous mass, insoluble in water, but soluble in alcohol and ether. Acids intensify the red color, alkalies convert it to a bluish green, in which respect it acts like *hæmatoxylin*.

H. H. Rusby.

ALLANTOIS.—(From N. L., *allantoides*; Greek, *ἀλλᾶς* (*ἀλλάντ*), a sausage, and *εἶδος*, form: sausage shaped.) The allantois is one of the fœtal membranes peculiar to the group of higher vertebrates in which the embryo is enveloped in an amnion, the Amniota.

It is homologous with the highly vascular urinary bladder of the Amphibia.

In the Amniota the embryo is formed from a comparatively small part of the blastoderm (see *Area Embryonalis*). At an early stage of development the mesoderm becomes divided into two layers of cells, with

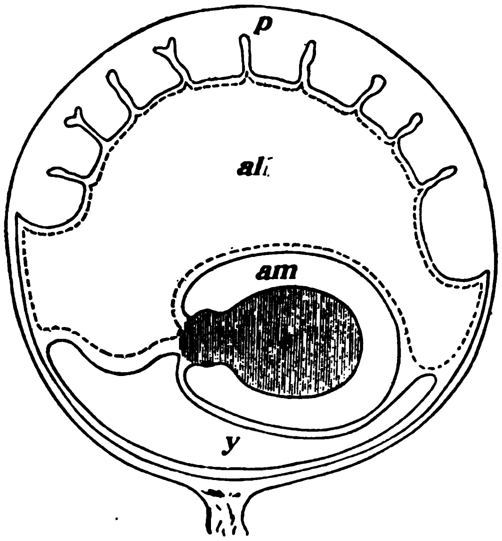

FIG. 81.—Fœtal Membranes of the Mole. *e*, Embryo; *am*, amnion; *all*, allantois; *p*, placenta; *y*, yolk sac. (After Strahl.)

a cavity between known as the *cœlom*, a part of which becomes the body cavity. The outer layer unites with the ectoderm to form the *somatopleure*, which gives rise to the body wall, the amnion (see *Amnion*) and the false amnion, or chorion; while the inner layer unites with the entoderm, or hypoblast, to form the *splanchnopleure*, which gives rise to the wall of the digestive tract and its appendages and to the wall of the yolk sac (see *Fœtus*). During the formation of the tail fold of the embryo, the splanchnopleure folds in more rapidly than the somatopleure, so that a cœlomic space is left between the two beneath the newly formed posterior end of the intestine. From the ventral wall of this part of the intestine a pocket grows out into the cœlom. This pocket is the *allantois*. It is made up of two layers of cells, entoderm and splanchnic mesoderm. It grows out rapidly as a thin-walled sac between the amnion and the yolk sac, and blood-vessels develop in its mesodermal tissue. In the placental mammals the distal portion of the allantois fuses with the chorion and forms the essential part of the fœtal portion of the placenta (see *Placenta*), while the proximal part becomes dilated to form the urinary bladder, and a part of the middle portion finally loses its lumen and persists as the urachus, connecting the bladder with the umbilicus.

In regard to the details of its origin, its structure, and its relations to adjacent parts, the allantois varies greatly in different groups of animals. Among the mammals the most diagrammatic arrangement is to be found in the mole, one of the Insectivora, a group that shows many primitive characters. According to Strahl, in a cross section of a gravid uterus of the mole, *Talpa europæa* (Fig. 81), one may see the embryo surrounded by the amnion, except on the ventral side, where the yolk sac and the allantois are attached. The allantois has a large lumen, which occupies the greater part of the space between the embryo and the chorion. Its outer wall fuses with the chorion, and the greater part of it gives rise to the thickened placenta. On the opposite side the smaller yolk sac spreads out in a similar way and likewise fuses with the chorion, but its outer surface does not become vascular like that of the allantois. Except for the increase in the size of the embryo and the corresponding reduction in the lumina of the allantois and yolk sac, these relations persist until the end of gestation.

Going downward in the scale from the Insectivora to the Marsupials, in which the young are born in a very imperfect condition and no true placenta is formed, we find the relation between allantois and yolk sac reversed. In this group the allantois remains comparatively small, and in the opossum, according to Selenka, it does not even touch the chorion; and it begins to degenerate before birth. The yolk sac, on the other hand, is large, filling most of the space between the embryo and the chorion. It fuses with the latter, becomes highly vascular, and serves during fœtal life both as an organ of nutrition and as one of respiration.

In the most primitive of living mammals, the Monotremes, which lay eggs, the relation of the fœtal membranes is essentially similar to what obtains in the Sauropsida, the birds and the reptiles.

We may take the common hen as a type of the Sauropsida. At about the thirty-sixth hour of incubation the rudiment of the allantois first appears as a shallow pocket

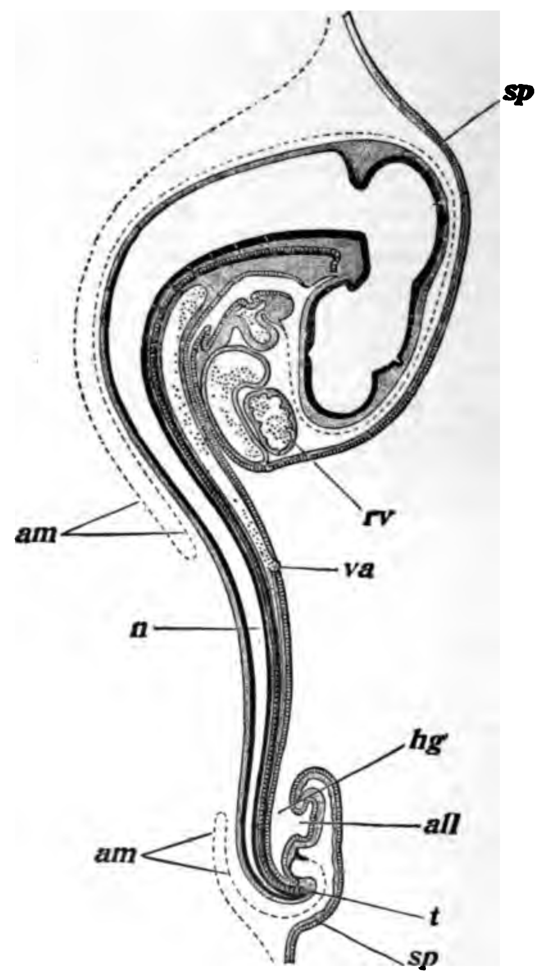

FIG. 82.—Median Longitudinal Section through a Chick Embryo at the End of the Third Day of Incubation. × 20. *all*, Allantois; *am*, amnion; *hg*, hind gut; *n*, neural canal; *rv*, right ventricle of the heart; *sp*, splanchnopleure; *t*, tail. (After Marshall.)

in the entoderm, at the extreme posterior end of the embryo. As the formation of the tail fold progresses, this comes to lie on the ventral side of the hind gut (Fig. 82). By the end of the fifth day it has grown out between the yolk sac and the amnion, as a vesicle of considerable size. It then grows rapidly until, uniting with

the chorion, it spreads out as a large, thin-walled, highly vascular sac, and completely surrounds the amnion and yolk sac. It serves as the organ of respiration for the embryo. Finally a part of it nearly surrounds the remnant of the albumen and probably assists in its absorption (Fig. 83). A short time before hatching, its vessels are cut off by the closure of the umbilicus, it dries up, and is left behind when the chick emerges from the shell.

The allantois has essentially the same history in most reptiles. In a lizard (Lacerta), according to Strahl, confirmed by Corning and Janosik, it arises in a peculiar way independently of the gut and comes into connection with it secondarily. And Giacomini found that in another lizard, which brings forth its young alive, *Seps chalcides*, it probably has a nutritive as well as a respiratory function. In this species both the allantois and the yolk sac fuse with the chorion, forming an allanto-chorion and an omphalo-chorion. The egg is very small, without envelopes, and the allanto-chorion becomes folded into a series of ridges and hollows which fit into corresponding inequalities in the wall of the oviduct, forming a kind of placenta. A similar but less perfect connection is formed by the omphalo-chorion.

Starting again from the diagrammatic form of allantois found in the mole, and going upward in the scale, we find in the Ruminants a large allantois of comparatively simple structure.

According to Bonnet, the rudiment of the allantois appears in the sheep at about the end of the fifteenth day after copulation. The tail fold has not yet formed, and the allantois appears as a sac-like posterior prolongation in the axis of the enfolding gut. With the development of the tail fold the allantoic stalk gradually assumes its

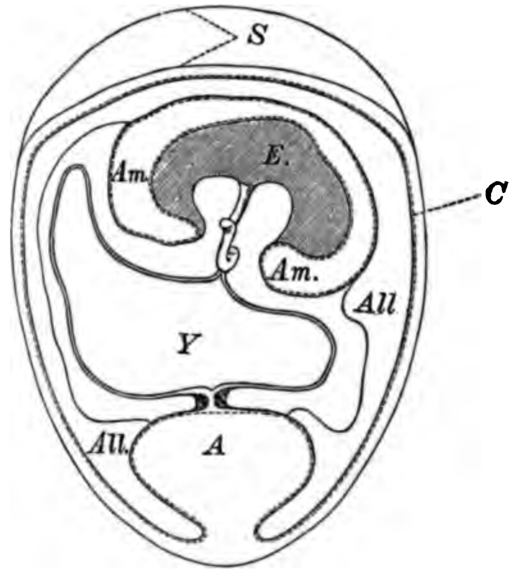

FIG. 83.—Diagram of the Fœtal Membranes in a Hen's Egg. *A*, Remnant of the albumen; *All*, allantois; *Am*, amnion; *C*, chorion; *S*, shell membrane; *Y*, yolk. (After H. Virchow, from Strahl.)

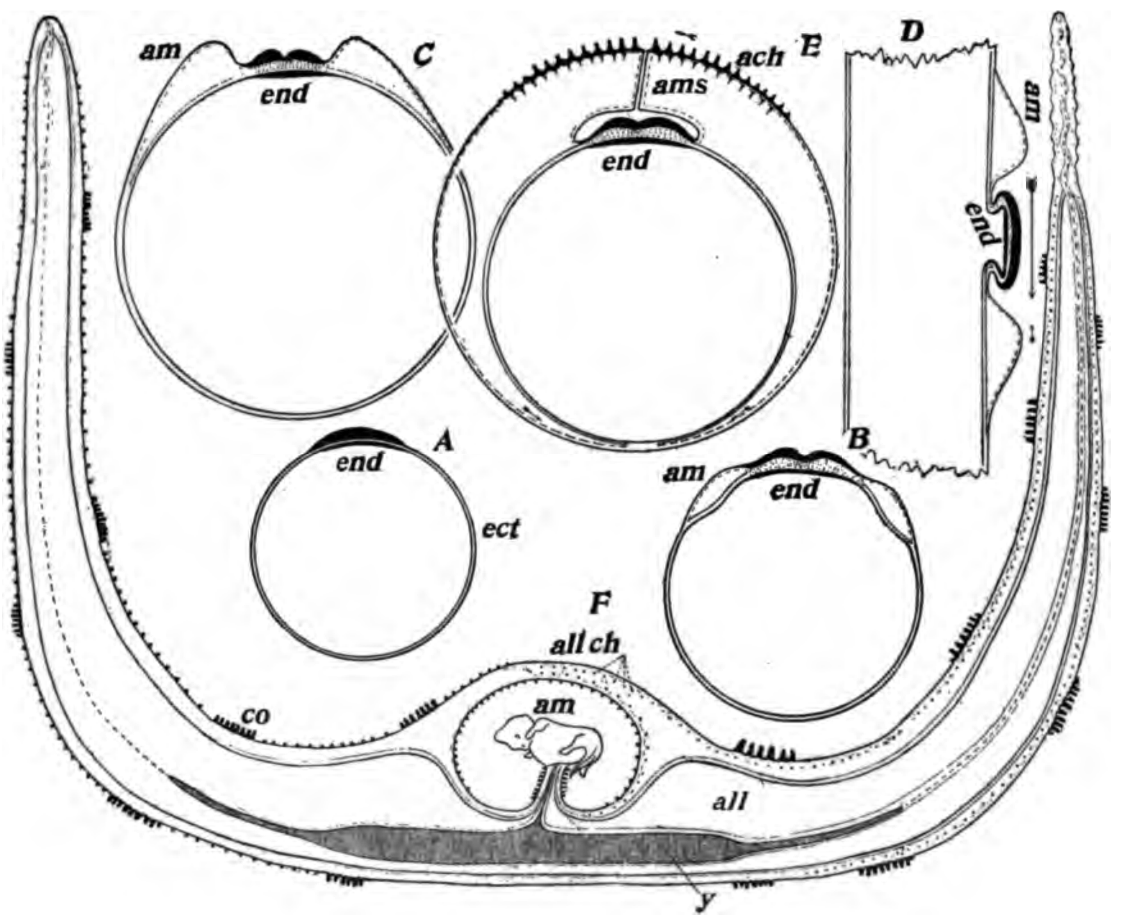

FIG. 84.—Diagrams Showing the Development of the Fœtal Membranes of the Sheep. *A*, Transverse section on the twelfth day after copulation; *B*, thirteenth day; *C*, about the same age; *D*, longitudinal section about the same age; *E*, transverse section of an older embryo; *F*, diagram of the fœtal membranes at the end of the first month; *all*, allantois; *all ch*, allanto-chorion; *ach*, amniogen chorion; *am*, amnion; *ams*, amnion stalk; *co*, cotyledon; *ect*, ectoderm; *end*, entoderm; *y*, yolk. (After Bonnet.)

normal position as an appendage of the hind gut. Very soon the young allantois begins to spread latterly, so that by the end of the sixteenth day it has become a half-moon-shaped appendage nearly half as large as the embryo. From this time on, its growth is rapid until it extends the whole length of the chorion. As it becomes

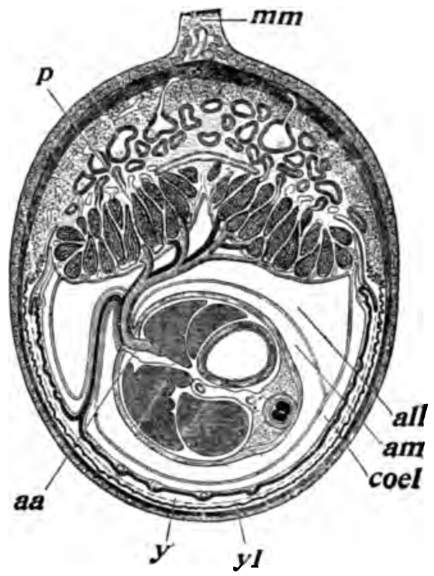

FIG. 85.—Transverse Section through the Gravid Uterus of a Rabbit at the End of the Nineteenth Day of Gestation. × 1¾. *aa*, Allantoic artery; *all*, allantois; *am*, amnion; *coel*, cœlomic space; *mm*, mesometrium; *p*, placenta; *y*, cavity of yolk sac, which is continuous with the uterine cavity owing to the absorption of the lower wall of the yolk sac represented by the dotted line *yl*. (After Marshall.)

distended with liquid its mesodermal layer is pressed closely against that of the chorion, and the two fuse and form the important placental structures. At the twenty-first day, when the embryo is about a third of an inch in length, the allantois is a large sausage-shaped bag measuring more than a foot from tip to tip. The embryo enveloped in its relatively small amnion lies in a depression at the centre of the allantois, and the yolk sac has dwindled to a hollow, thread-like structure lying in a groove in one side of the allantois and extending in both directions to the ends of the chorion (Fig. 84 *F*).

The Carnivora have likewise an allantois with a large lumen. The allantois at first bends dorsally and enlarges into a mushroom-shaped sac. Its outer wall unites with the chorion and forms at first a discoidal placenta. But the allantois continues to enlarge until it has fused with the whole inner surface of the chorion. It completely surrounds the amnion, containing the embryo, and finally encloses also the yolk sac. At the same time the placenta extends around the equator of the egg as a broad band, and finally acquires its characteristic zonary form.

In the Rodentia the allantois unites with only a part of the chorion on the dorsal side of the embryo, the rest of the chorion being fused with the large flattened yolk sac. In this group there are two types of allantois. One of these is represented by the rabbit, and has a large persistent lumen. In the other type, represented by the rat and the guinea-pig, the lumen is very small or may disappear altogether. According to Fleischmann, the squirrel presents a form of allantois intermediate between these two types. Aside from these differences in the allantois, the rodents are generally alike in having a large omphalo-chorion, a smaller discoidal placenta, a small amnion, and a large cœlomic cavity filled with fluid, separating the allantois from the yolk sac (Fig. 85).

In man the allantois is a highly specialized structure, and the first stages in its development occur at a very early period. When the amnion is fully formed and separated from the chorion, the posterior end of the embryo remains attached to the chorion by a thick cord of mesodermal cells, in which the allantoic vessels are formed, and which may be regarded as the precociously developed wall of the allantois. The early stages are not well known, but eventually the lumen of the allantois is developed within this cord as a narrow tube lined with entodermal cells, extending backward from the end of the hind gut to the chorion. It is formed, then, in the same position as in the sheep, but its subsequent history is very different, for it persists as a small tube usually until the end of fœtal life; while the allantoic vessels spread far from the lumen into the mesodermal lining of the chorion and supply the fœtal circulation of the placenta (Fig. 86.)

The allantoic fluid of the cow has been shown by Döderlein to differ from the amniotic fluid in being poorer in salts of sodium and richer in nitrogen. The latter increases with the age of the fœtus, indicating that it is an excretory product; and according to Foster and Balfour urates are abundant in the allantoic fluid of the chick by the sixteenth day.

The circulation in the allantois takes place primarily through two pairs of blood-vessels, the allantoic or umbilical arteries, and the allantoic veins and their branches. The allantoic arteries arise as direct prolongations of the primitive forks of the aorta. When the hind limbs bud out, the external iliac arteries arise as branches of the allantoic arteries. In the chick the right allantoic artery does not grow so fast as the left, and it finally dwindles and disappears altogether. In man the two arteries persist. They may be traced from the posterior end of the aorta through the umbilical cord (see *Umbilical Cord*) to the placenta, where they branch freely.

The two allantoic veins in the chick are formed during the fourth day. They unite in the body of the embryo, becoming there a single allantoic vein, which passes forward on the left side and joins the left vitelline vein. In man and other mammals the two allantoic veins at first open into the sinus venosus, one on each side, in company with the corresponding Cuvierian and vitelline veins. Later, while the allantoic veins remain distinct within the embryo, in the allantoic stalk they fuse to form a single vessel. During the fourth week in man the allantoic veins become separated from the sinus venosus. The smaller, right one soon after disappears, while the left one unites with the portal vein (formed by the union of the vitelline veins) and increases in size.

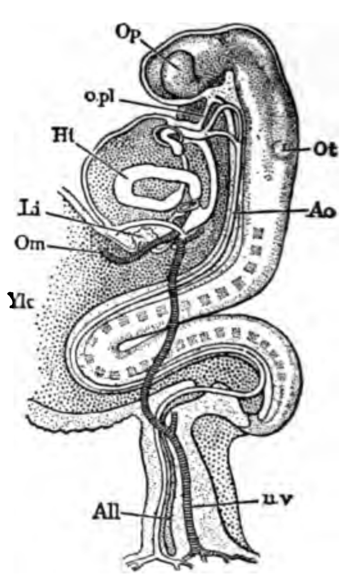

FIG. 86.—Human Embryo of 2.15 Mm., Reconstructed from Sections. *All*, Allantois; *Ao*, aorta; *Ht*, endothelial heart; *Li*, liver; *Om*, omphalo-mesenteric vein; *uv*, allantoic vein; *Yk*, yolk sac. (From Minot, after His.)

Creighton has described recently (1899) a series of lymphatic cylinders and capsules surrounding certain allantoic vessels in the chick. They are found upon the vessels where the allantois and amnion come into contact, and are supposed to aid in the absorption of the yolk and albumen. (For a description of the circulation in the placental portion of the allantois, see *Placenta*.)

The principal adult structure developed from the al-

lantois is the urinary bladder. Of that part of the allantois which lies within the body of the embryo, the proximal portion begins to enlarge during the second month to form the bladder, while the tapering distal portion finally loses its lumen and becomes the urachus, or ligamentum vesicæ medium, connecting the bladder with the umbilicus. The portions of the allantoic arteries within the embryo are called the hypogastric arteries, and are more or less homologous with arteries of the same name in lower vertebrates. At birth the distal part of the hypogastric on each side loses its lumen and becomes a solid cord enclosed in the superior ligament of the bladder, while the proximal part persists as the common iliac, internal iliac (as far as the bifurcation), and superior vesical arteries. The remaining allantoic, or umbilical, vein loses its cavity at birth and becomes the ligamentum teres, or round ligament, connecting the liver with the umbilicus (see *Fœtus*).

Robert Payne Bigelow.

ALLEGHANY SPRINGS.—Montgomery County, Virginia.

POST-OFFICE.—Alleghany Springs.

ACCESS.—Via Norfolk and Western Railroad to Shawsville station, thence by carriage or omnibus three and a half miles to springs. Hotel and cottages.

This well-known resort is located on the eastern slope of the Alleghanies, on the head waters of the Roanoke River. The hotel and principal range of cottages occupy smooth and undulating hills, gently sloping to a broad, grass-covered lawn of forty acres, extending to the banks of the river. The accommodations here are first class, affording every convenience and comfort to the pleasure seeker as well as the invalid. The hotel is large and spacious, and is supplied with all requisite improvements. Contiguous to the hotel are one hundred and fifty double cabins, arranged with a view to the comfort and good health of the guests. The scenery in the vicinity is not excelled for picturesque loveliness and variety at any watering place in the Old Dominion. Only one spring, which flows about thirty gallons per hour, is in use at the present time. The water is limpid, and has a temperature of 56° F. The following analysis was made some years ago by Dr. F. A. Genth, of Philadelphia:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	3.61
Magnesium carbonate	0.36
Lithium carbonate	Trace.
Strontium carbonate	0.06
Barium carbonate	0.02
Magnesium carbonate	0.06
Iron carbonate	0.16
Cobalt carbonate	Trace.
Zinc carbonate	Trace.
Copper carbonate	Trace.
Lead carbonate	Trace.
Sodium sulphate	1.72
Calcium sulphate	115.29
Magnesium sulphate	50.88
Potassium sulphate	3.70
Magnesium nitrate	3.22
Aluminum nitrate	0.56
Aluminum phosphate	0.03
Aluminum silicate	0.21
Sodium chloride	0.28
Calcium fluoride	0.02
Antimonium oxide	Trace.
Silica	0.88
Crenic acid	Trace.
Apocrenic acid	Trace.
Organic matter	2.00
Total	183.06
	Cub. In.
Gases. Carbonic acid	0.56
Gases. Sulphureted hydrogen	Trace.

According to the author's classification, this water may be denominated a magnesic-sulphated saline. It is distinguished for the great variety of its mineral constituents. When taken in large doses it is actively diuretic and cathartic, operating with special activity on the mucous membrane of the lower intestines. In smaller doses its action may be described as tonic, alterative, and detergent. The water has been found particularly beneficial in the treatment of dyspepsia, for which it has a wide reputation. Excellent effects are also observed in nervous affections and in diseases of the liver and kidneys. It is recommended in small doses by many physicians in the treatment of anæmia and chlorosis, general debility, and other conditions in which tonic and reconstructive effects are sought. The water is used commercially.

James K. Crook.

ALLEN SPRINGS.—Lake County, California. These valuable springs are situated in the Coast Range Mountains, three miles east of Bartlett Springs, and some forty miles west of the town of Williams. The location is in a cañon at the head of Cache Creek, at an elevation of eighteen hundred feet above the Pacific Ocean. The grounds are delightfully shaded by huge oaks and towering pines and surmounted by evergreen hills. The usual excellent climatic conditions of Lake County prevail here. Good hunting and fishing will be found in the neighborhood. There are five springs on the place, two containing considerable iron, while three are of the alkaline saline type. All the waters contain carbonic acid gas and are cool and sparkling. The following analysis of the soda spring was made by Dr. Winslow Anderson in 1888:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	23.16
Sodium bicarbonate	4.25
Sodium sulphate	0.78
Potassium cnloride	1.90
Magnesium bicarbonate	27.40
Potassium bicarbonate	0.75
Magnesium chloride	63.00
Calcium bicarbonate	20.14
Calcium phosphate	0.55
Ferrous carbonate	0.93
Organic matter	Trace.
Total	142.86
	Cub. In.
Carbonic acid gas	36.00

According to Professor Wenzell's analysis, silica is also present. These waters are gently aperient in action, and have gained considerable reputation in chronic hepatic and renal affections, associated with dropsy. The resort has ample accommodations for guests, besides good bathing facilities.

J. K. C.

ALLIGATOR PEAR.—(*Avocado; Abogate; Palta; Midshipman's Butter.*)

The above are the names of the fruit of *Persea gratissima* Gaertn., a large tree of the *Lauraceæ*, and they are also applied to the seeds, which have distinct medicinal properties. The genus is very closely related to that yielding cinnamon. It contains about a dozen species, which grow in the tropics of both continents, but the one under discussion alone possesses the properties here described. It is native in many parts of the American tropics, and is largely cultivated in all tropical countries for its fruit, which is common in northern markets. This is inequilaterally elongated-pyriform, and as large as the very largest pears. The skin has a leathery, rusty-green appearance. The solitary ovoid seed fills half of the interior, the remaining space being occupied by a creamy white pulp, penetrated by numerous gray or greenish veins, of the finest and smoothest fatty texture, highly nutritious and of peculiar flavor. On first trial, it is disgusting to most persons, but they usually become extravagantly fond of it on continuing to use it. The juice of the seeds makes indelible stains on linen, and is used for this purpose. The seeds are largely used in the tropics as a local application in rheumatism and neuralgia, and some physicians have thus found the fluid extract of service. They are also credited with anthelmintic properties, and doses of fl. ʒ i. of the fluid extract have been used to expel tænia.

H. H. Rusby.

ALLOUEZ MINERAL SPRINGS.—Brown County, Wisconsin.

POST-OFFICE.—Green Bay. Hotels in Green Bay.

The Allouez Springs are beautifully located near the base of an elevation (Astor Heights) in the southern part of the city of Green Bay. This charming city, which lies at the head of the bay of the same name, is one of the oldest settlements of the Northwest. In the year 1668 Father Allouez established a military station here, and from that period dates the first settlement of the city. The springs are located but a short distance from the site of the old mission, and are named in honor of its intrepid and worthy founder. The water bubbles out from the hillside at a uniform rate all the year. It has a temperature of 46° F. A pretty park surrounds, and an ornamental pavilion covers the spring, which gushes up through an octagonal marble basin. An attendant in charge supplies water to the visitors. It is believed that the Menominee Indians used the spring for medicinal purposes. The water was analyzed in 1888 by Prof. W. W. Daniels, of the Wisconsin State University, with the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	4.26
Potassium sulphate	0.12
Sodium sulphate	3.46
Calcium sulphate	0.11
Sodium phosphate	Trace.
Iron bicarbonate	0.06
Calcium bicarbonate	24.69
Magnesium bicarbonate	27.53
Alumina	0.17
Silica and insoluble residue	1.97
Total	62.37

In his work on the mineral waters of the United States the writer has classified this as an alkaline-saline-calcic mineral water. It contains a very fortunate combination of mineral ingredients. The principal component, the bicarbonate of magnesia, gives it valuable antacid and laxative properties. The latter action is aided somewhat by the presence of sulphate of sodium. Authorities are agreed that the carbonate of magnesia is an excellent antilithic in those cases in which uric acid is too abundant. The small proportion of bicarbonate of iron which the water contains is sufficient to impart to it tonic effects. The chloride of sodium, sulphate of sodium, and bicarbonate of magnesium, all contribute to render the water diuretic. In diseased states its best effects have been observed in diabetes, Bright's disease, disorders of the stomach and liver, and in gout, rheumatism, and vesical calculi. The water is soft and sparkling, and, as it contains no trace of organic or vegetable matter, is well adapted for general table use.

Green Bay offers numerous advantages as a health resort. Its elevated location renders the air cool and refreshing during the summer months, and malaria is unknown. The magnificent Fox River, which flows into the bay at this point, is spanned by five bridges. The streets are embowered with avenues of grand old trees, and there are excellent drives in all directions for miles around. Small steam and sailing yachts, with their burdens of pleasure seekers, ply the placid waters of the bay, forming, during the spring and summer months, a picture of serene and restful beauty.

James K. Crook.

ALLSPICE (PIMENTA).—"The nearly ripe fruit of *Pimenta officinalis* Lindley (fam. *Myrtaceæ*)" (U. S. P.). The source of this fruit is a handsome, evergreen, fragrant tree, about 10 metres (30 feet) in height, with opposite, dark-green, shining leaves and small white flowers. The fruit is a rather dry, two-celled and two-seeded drupe, from 0.5 to 1 cm. (one-fifth to two-fifths inch) in diameter, nearly spherical, and crowned with its four-parted calyx and short cylindrical style.

The allspice tree is a native of the West Indies, South and Central America, and Mexico. It is abundant in the island of Jamaica, both wild and cultivated, and has been introduced into Asia and other tropical places.

This spice has been used in Europe for more than two centuries, and is still in great demand, both there and here, as a domestic condiment. It comes almost entirely from Jamaica, where it is obtained in enormous quantities, from both wild and cultivated trees. The fruits—like those of pepper and cubebs—are collected just before they are ripe and dried in the open air. When fully ripe, a portion of the fragrance is lost. The dried fruits are slightly smaller than the fresh; spherical or nearly so, finely wrinkled or tuberculated upon the surface, of a brown or grayish-brown color, and having a strong, agreeable, aromatic, clove-like odor. The limb of the calyx is usually rubbed away, leaving a circular projecting margin, or crown, at the apex of the fruit, enclosing a shallow, saucer-shaped calyx cup, from the middle of which rises the style, usually broken off at the top. The seeds are brown, flattish, exalbuminous, the embryo spirally coiled. A section of the fruit reveals, just below the surface, numerous large oil cells, some of which, projecting outward, form the small corrugations to be seen upon the outside. These cells contain most of the oil; in the seeds are fewer and smaller oil cells.

FIG. 87.—Pimenta Officinalis, Fruit (entire).

FIG. 88.—Longitudinal Section of Same (enlarged).

The oil of allspice (*Oleum Pimentæ*, U. S. P.), which is its only valuable constituent, can be obtained to the extent of two to four per cent. With this, occur fixed oil, resin, tannin, and gum. Allspice is little used medicinally, in doses of 0.5 to 2 gm. (gr. viij.–xxx.), as an ordinary aromatic, similar to cloves, but weaker. There is no official preparation, though it enters, as a carminative and flavor, into several official preparations.

W. P. Bolles.

OIL OF ALLSPICE (Oil of Pimenta.)—"A volatile oil distilled from pimenta" (U. S. P.). This is a thin, transparent liquid, at first colorless, becoming yellow or even brownish, and thicker with age. It has the odor and somewhat the taste of cloves. Its specific gravity is 1.040 to 1.050. Its active constituent is *eugenol*.

H. H. Rusby.

ALLYL TRIBROMIDE.—Tribromhydrin, tribrompropheny, $C_3H_5Br_3$, is obtained by the action of bromine on oil of garlic (allyl sulphide). It is a heavy, colorless, or faintly yellowish liquid, which is insoluble in water and soluble in alcohol, ether, volatile and fixed oils. Liquid at ordinary temperature, it solidifies at 10° C. (50° F.). This remedy, containing as it does eighty-five per cent. of bromine, may well replace the alkaline bromides as sedative and antispasmodic. In asthma, pertussis, laryngismus stridulus, nervous irritability, and especially in epilepsy it has had a marked effect. In hysteria, on the other hand, it has been of no value. Its dose is 3 to 10 minims, given in capsule or on sugar, two or three times a day; or it may be given hypodermically dissolved in 10 or 20 minims of ether or oil. *W. A. Bastedo.*

ALMONDS, BITTER AND SWEET.—AMYGDALA AMARA, *Bitter Almond.* "The seed of *Prunus Amygdalus amara* D. C. (fam. *Rosaceæ*)" (U. S. P.).

AMYGDALA DULCIS, *Sweet Almond.* "The seed of *Prunus Amygdalus dulcis* D. C. (fam. *Rosaceæ*)" (U. S. P.).

The almond tree is a small tree, inhabiting the countries bordering the Mediterranean Sea, Greece, Asia Minor, Syria, Algeria, as well as Abyssinia and other Eastern lands. It has been cultivated also in many of these places from time immemorial. It is very similar in size and appearance, as well as leaf and flower, to its near ally, the peach, growing from 5 to 10 metres (16 to 32 feet) in height, with graceful branching top.

The leaves are oblong, lanceolate, finely serrated, simple, and give when bruised a peachy odor. The flowers are large, pale rose colored, almost exact counterparts of those of the peach. But the fruit, although structurally similar, develops differently: that part (the sarcocarp) which in the peach becomes juicy and edible, in the almond dries up, splits, and falls away, leaving the stone (putamen) attached to the tree. This is then gathered and makes the almond of commerce, while the seed, removed from the stone, is the official almond.

The former is oblong-ovate, pointed, yellow, somewhat flattened, with blunt or sharpish borders, and a roughish surface, perforated with numerous pores and depressions. The shell is variable, usually hard enough to require a light hammer to break it; in some varieties it is easily crushed between the thumb and forefinger. The seed is sometimes, in some varieties always, imported without the shell. It is solitary and exalbuminous.

Long cultivation has produced many horticultural varieties of almonds, depending mostly upon their size, shape, and thickness of shell; but the most important distinction is that of taste and composition, in respect to which these varieties fall into one or another of two series, namely, those with bitter, and those with sweet or bland seeds. The trees producing them do not differ from each other much, excepting in the character of the seeds, but yet appear to be distinct, both existing in the wild state.

The chief source of almond production is the Mediterranean region, though it may be cultivated in almost any warm, temperate, or subtropical country. There are so many varieties of both almonds, and these differ so greatly in size and form, that comparative descriptions are difficult. Those used as drugs are about an inch in length, ovoid, with strongly rounded base and obtusely pointed apex, flattened so as to be three times as broad as thick, and about one-half longer than broad. The surface is of some shade of brown, more or less wrinkled, scurfy, with a dense covering of short, thick, microscopical hairs, and with numerous lines radiating from the base. The kernel consists entirely of two oily cotyledons of the same form as the seed, in contact by their flat faces, and of a nearly white color. They have a faint characteristic odor.

In general, the bitter almond is of a darker color, a little shorter, broader, and flatter, and a little less wrinkled than the sweet. It has a characteristically bitter taste, the sweet ones being entirely bland, sweet, oily, and nutty.

Of sweet almonds, the important constituent is fifty per cent. or more of a fixed oil (see *Oleum Amygdalæ Expressum*), which occurs with about three per cent. of gum and six per cent. of sugar, and a large amount of albuminoid matter. There is a very small amount of tannin in the seed coat. Their properties are purely demulcent and nutritive. We have an official emulsion and a syrup which are used as vehicles.

In composition, bitter almonds have about one-sixth less of the same fixed oil, and contain from one to three per cent. of the peculiar glucoside (see *Amygdalin* and *Emulsin*) which yields hydrocyanic acid and benzaldehyde, as described under *Hydrocyanic Acid*. The yield of oil of bitter almond is about one per cent., that of prussic acid about .06 to .18 of one per cent., of the weight of the seeds.

It is evident that the bitter almond combines the properties of sweet almonds and prussic acid, and that an ounce of the drug is equivalent to almost one grain of the latter. It does not follow that the effect would be the same as that dose, inasmuch as the development of the acid would be neither so sudden nor so complete. Nevertheless, bitter almonds must be regarded as poisonous. Even a small number of them, if eaten, are apt to produce a slight gastric irritation as an after effect. There is no official preparation of bitter almond, except that a little of it enters into the composition of *Syrupus Amygdalæ*. Its chief use is as a flavoring agent, though small doses are used for their sedative effect.

Peach seeds are often used to adulterate bitter almond, and their composition is very similar. Sweet almonds are also used as an adulterant. *H. H. Rusby.*

ALOES.—The inspissated juice of the leaves of various species of *Aloe*, a genus of nearly a hundred species, in the family *Liliaceæ*, widely distributed through tropical Africa, on the continent and islands, and at least two species extending, through introduction, into Asia, and one into Southern Europe and the West Indies.

They are plants of desert or arid regions and strongly succulent, as is common among plants of such localities. They have large, fleshy, bayonet-like leaves, densely arranged in a distichous or tristichous manner, and tall spikes of fleshy flowers, often similarly arranged. All methods of producing aloes from them are based upon the fact that they contain two distinct juices, the one thin and flowing at once when the leaves are cut, the other thicker and not readily flowing except under pressure. It is the former of these juices which yields the drug, and which is therefore allowed to flow from the cut leaves without pressure.

This juice is then inspissated, either spontaneously or by boiling, and yields a yellow, yellow-brown, gray-brown, green-brown, or nearly black mass, which may be hard and brittle or of a soft, tarry consistency, or of any intermediate degree. It may be dull, waxy, or glassy, and opaque or translucent, and its odor varies greatly. It is thus seen to be unfitted for any general description.

The places of manufacture give the names to the different commercial sorts. It is one of the oldest of medicines; valued—according to tradition—long before the Christian era. Certainly it was known to the Greeks and Romans of the first century, and to the rest of Europe during the Middle Ages. It has always been extensively used and highly prized, as the fanciful names given to many of the older aloes compounds testify. The variety earliest known, socotrine aloes, is, singularly too, the same which is still considered the best in England and America, and is nominally obtained from the same little, obscure, out-of-the-way island that Alexander is reported to have peopled with Greeks, in order to protect and improve its production. Of all the known commercial varieties of aloes, the U. S. P. recognizes but two, as follows:

Aloe Barbadensis (*Barbadoes Aloes* or *Curaçoa Aloes*) is yielded by *Aloë vera* (L.) Webb. The name "Barbadoes aloes" indicates the former rather than the present geographical source, which latter is better expressed in the term "Curaçoa aloes." It was formerly produced in both islands, the Curaçoa coming in large blocks, run into boxes, the Barbadoes in gourds. Later, the latter article largely disappeared from commerce. Still more recently, the other has been put up in gourds after the Barbadoes style. It would appear, therefore, that practically all of our so-called Barbadoes aloes is now of Curaçoa production. The difference is, however, chiefly technical, as the parent plant, the process of manufacture, and the properties are identical in the two articles. This plant is the most widely distributed of the genus, growing through Northern Africa, Southern Europe, and the East Indies, as well as in the West Indies, where it is cultivated for the production of aloes. It grows to a height of nearly two feet, with a thick head of bluish-green, blotched leaves, and a dense spike of greenish-yellow flowers, each a little more than an inch in length, and of an elongated, contracted-campanulate form. From the *Pharmacographia* the following account of the preparation of Barbadoes aloes is quoted:

"The cutting takes place in March and April, and is performed in the heat of the day. The leaves are cut off close to the plant, and placed *very quickly*, the cut end downward, in a V-shaped wooden trough, about four feet long and twelve to eighteen inches deep. This is set on a sharp incline, so that the juice which trickles from the leaves very rapidly flows down its sides, and finally escapes by a hole in its lower end into a vessel placed beneath. No pressure of any sort is applied to

the leaves. It takes about a quarter of an hour to cut leaves enough to fill a trough. The troughs are so distributed as to be easily accessible to the cutters. Their number is generally five, and by the time the fifth is filled, the cutters return to the first, and throw out the leaves, which they regard as exhausted. The leaves are neither infused nor boiled, nor is any use afterward made of them, except for manure.

"When the vessels receiving the juice become filled, the latter is removed to a cask and reserved for evaporation. This may be done at once, or it may be delayed for weeks, or even months, the juice, it is said, not fermenting or spoiling. The evaporation is generally conducted in a copper vessel; at the bottom of this is a large ladle, into which the impurities sink, and are from time to time removed as the boiling goes on. As soon as the inspissation has reached the proper point (which is determined solely by the experienced eye of the workman), the thickened juice is poured into large gourds, or into boxes, and allowed to harden."

This product varies from an orange brown (Curaçoa aloes, usually) to a chocolate brown. The latter when broken up exhibits the orange-brown color also. It is commonly of a waxy lustre, dry and brittle or friable, but is occasionally harder and of a glassy lustre. Its peculiar odor constitutes its most characteristic feature. It is the chief source of *Aloin*, and is regarded as a very good article, though cheaper and less desired than the next. A large amount of it is, however, sold under the title of the next.

Aloe Socotrina (*Socotrine Aloes*) is yielded by *Aloe Perryi* Baker. From Socotra the drug was formerly brought into Europe via the Red Sea and Alexandria. After the discovery of the route around the Cape of Good Hope, it followed the course of commerce in that direction; at present, Socotrine aloes is apt to go to India, and from there to England, with the enormous mass of Indian products.

It comes from various parts of Eastern Africa. The preparation of Socotrine aloes is said to differ from that of Barbadoes, in that the heat of the sun is relied upon for its evaporation. Although sometimes imported in large barrels, it is usually in small kegs or small skins. The latter is a cheaper grade, dry and brittle, the former a soft-solid, at least at the centre, where it is frequently very soft, so as to flow. Socotrine aloes is typically of a brownish yellow or yellow brown, rather than an orange brown like the last, but it is occasionally darker, nearly of a brown black. There should never be any hint of green in its color. If exposed to the atmosphere, it at length becomes hard, through evaporation. Its odor is much finer than that of Barbadoes. Although not, strictly speaking, less strong, it is less rank and heavy. It is its odor which is relied upon for identification, as well as for an indication of its quality.

Both official varieties are described as having a saffron-like odor. It is said that if the nearly liquid varieties are allowed to stand, they will separate into a nearly black upper stratum and an orange-brown crystalline sediment. It is assumed that the darker or lighter colored varieties depend upon varying proportions of these two component parts. Both varieties are mostly soluble in alcohol and water, the Socotrine more slowly in the latter.

Both, on being dissolved in water or alcohol, yield a crystalline sediment of aloin. Both consist chiefly of a resin-like substance which is soluble in alcohol and hot water, but precipitated from the latter solution by boiling. A small amount of volatile oil is found in both. *Aloin* is about five times as active as aloes.

Aloe Purificata, U. S. P., is Socotrine aloes which has been heated, dissolved in alcohol, strained through a No. 60 sieve, evaporated, cooled, and broken up.

Considering its immense importance as a drug, the action of aloes is a remarkably simple one. Aside from its action in the mouth and stomach as a simple bitter, its operation is almost entirely confined to the lower part of the large intestine, where, by its irritant properties, it powerfully stimulates peristalsis and moderately stimulates secretion. It is therefore a very dilatory, but quite active cathartic. Its action is quite apt to be griping and painful, especially to those affected with hemorrhoids. Although it has been claimed that this condition can be relieved by the skilful, continued use of aloes, this is doubtful; while it is certainly true that the condition is thus frequently aggravated in a serious degree. A diuretic effect frequently accompanies the purgation, and is probably in chief part due to a mere extension of the irritation. The same is to be said of its emmenagogue effect, and it is to be remembered that this may lead to abortion. The intensity of the action of aloes is quite variable, not only in different individuals, but in the same individual at different times, and this is especially true when aloin is used alone. This is believed to be due to variations in the solution of the aloin. The bile is its natural solvent. Glycerin acts similarly, and either of these solvents, injected into the rectum with aloes, will cause it to take effect. Taken internally, alkalies increase its activity, as does iron. Aloes can be absorbed by the subcutaneous tissue, excreted into the bowel and become active. Because of its slowness, and its limited field of action, it is usually preferred to combine it with some differently acting cathartic. Its peculiar mode of action indicates that aloes is especially useful in those cases of constipation which result from torpidity of the intestinal muscles.

The dose of aloes is exceedingly variable, according to the patient and the effect desired, being from 0.03 to 0.6 gm. (gr. ss.–x.).

The Pharmacopœia provides no preparation of Barbadoes aloes, but a large number of the purified Socotrine aloes, as follows:

LIQUIDS.—Tinctura Aloes, containing 10 per cent. of aloes and 20 per cent. of licorice root, made with 50 per cent. alcohol, dose 1 to 4 c.c. (fl. ʒ ¼–i.); Tinctura Aloes et Myrrhæ, containing 10 per cent. each of aloes, myrrh, and licorice root, made with 75 per cent. alcohol; dose the same as of the last.

SOLIDS.—Extractum Aloes (Aqueous), dose 0.03 to 0.2 gm. (gr. ss.–iij.); Extractum Colocynthidis Compositum, containing aloes 50 per cent., extract of colocynth 16 per cent., resin of scammony and soap, each 14 per cent., cardamom 6 per cent., dose 0.06 to 1.0 gm. (gr. i.–xv.): Pilulæ Aloes, each containing 0.13 gm. (gr. ij.), each of aloes and soap; Pilulæ Aloes et Asafœtidæ, each containing 0.09 gm. (gr. iss.) each of aloes, asafœtida, and soap; Pilulæ Aloes et Ferri, each containing 0.07 gm. (about gr. i.) each of aloes, dried sulphate of iron, and aromatic powder, with a little confection of rose; Pilulæ Aloes et Mastiches, each containing 0.13 gm. (gr. ij.) of aloes, 0.04 gm. (gr. ⅔) mastic, and 0.03 gm. (gr. ss.) of red rose; Pilulæ Aloes et Myrrhæ, each containing 0.13 gm. (gr. ij.) aloes, 0.06 gm. (gr. i.) myrrh, and 0.04 gm. (gr. ⅔) of aromatic powder, Pilulæ Rhei Compositæ, each containing 0.13 gm. (gr. ij.) rhubarb, 0.1 gm. (gr. iss.) aloes, 0.06 gm. (gr. i.) myrrh, and a little oil of peppermint.

UNOFFICIAL VARIETIES OF ALOES.—*Aloe Capensis*, or Cape aloes, is the hardest and most brittle variety, with a strong, usually glassy lustre and a very conchoidal fracture. It is usually blackish (brown black or greenish brown black), occasionally dark reddish brown. It has a very unpleasant odor, is not crystalline, and contains no aloin, and is mostly used in veterinary practice.

Aloe Natalensis, or Natal aloes, has a dull surface and a grayish-yellow brown color. It is crystalline and contains aloin, but is weak in odor and taste.

Hepatic aloes is a name which has come to be applied to any form having a distinct liver-brown color.

H. H. Rusby.

ALOPECIA.—Alopecia is a partial or general loss of hair, from any cause whatever, and that in sufficient quantity to be noticeable to the naked eye.

The word "alopecia" is derived from the Greek Ἀλώπηξ, meaning fox. Why this word has been used to express baldness, it is difficult to say. One explanation

might be that the fox is said to have, normally, two bald spots over his eyes, and another, that he is especially liable to the disease.

The term, as it is used to-day, covers a broader field than it did formerly. It includes not only all varieties and degrees of dystrophies and atrophies of the hair of the scalp, causing baldness, but also similar conditions of the hair upon any other part of the body.

In text-books the alopeciæ are usually divided into two main classes, congenital and acquired. In the present article this classification is not followed, but we will attempt to give a more scientific one instead.

Alopecia may be due to a local disease of some hairy part of the body, and in this case it would be limited throughout its whole course to the part in which it commenced, or it may be the result of disease elsewhere, and then the consequent baldness is only incidental to the other affection.

This line of thought also evolves two principal classes: (1) Alopeciæ essentiales, idiopathicæ sive primariæ; (2) Alopeciæ symptomaticæ sive secundariæ. The first class includes the congenital and senile forms, and those primary affections of the hair that are premature, comprising alopecia presenilis, alopecia pityrodes, alopecia areata, folliculitis decalvans, and dermatitis papillaris capillitii.

(*Note.*—We are well aware of the fact that strict logic would really not permit alopecia pityrodes to be placed in this class, but it stands out so prominently among those diseases causing baldness that for practical purposes it may be classed among the essential alopeciæ. Similar objections could be made against the placing of alopecia areata among the "idiopathic premature alopeciæ," and yet we find it there by the consent of many good authorities.)

The second class contains first, *alopecia toxica*, which includes those instances of alopecia caused by the use of drugs, like mercury and acetate of thallium and also those caused by the toxins of systemic infections such as syphilis, typhoid fever, etc.; second, *alopecia dynamica sive destructiva*, in which loss of hair is principally due to atrophy caused by mechanic force, such as pressure atrophy (lupus erythematosus), or to the destruction of tissue the result of suppuration (gummata, epitheliomata, sycosis, etc.), or to severe local inflammations (acute eczema, erysipelas, etc.); and finally, *alopecia neurotica*, which follows traumatic or functional nerve injuries.

The following represents a brief schedule of this classification:

I. *Alopeciæ Essentiales, Idiopathicæ sive Primariæ.*
 1. Congenita.
 2. Senilis.
 3. Prematura.

II. *Alopeciæ Symptomaticæ sive Secundariæ.*
 1. Toxica.
 2. Dynamica sive destructiva
 3. Neurotica.

I. Alopeciæ Essentiales Idiopathicæ Sive Primariæ.

1. ALOPECIA CONGENITA; DEPILATIO CONGENITA; ATRICHIA; OLIGOTRICHIA.

1. CONGENITAL ALOPECIA is a rare affection. It may be complete, the new-born babe being wholly devoid of hair, even of lanugo ones. After some time has elapsed, from a few months to a few years, let us say, lanugo hairs may begin to form, and later on, full-sized normal hairs may make their appearance. It may, however, be the case that growth of hair never takes place. This has been frequently found to be true where there was only a partial alopecia at birth. In an instance like this the individual bald patches may multiply in number until they spread over the entire scalp, and they often show a tendency to increase in size.

In connection with this malady, anomalies of the teeth and nails are often observed. Crocker reports the case of an individual who who had only four molar teeth, and was never known to have perspired or shed tears.

Etiology.—Alopecia congenita represents one of the evidences of arrested development; there is a marked hereditary tendency, and more than one member of the same household may suffer from it.

Pathology.—Schede is apparently the only one who has published a complete microscopical examination of this disease (*Archiv für klin. Chir.*, Bd. xiv.). He found the sebaceous glands well developed, in many places sending their open ducts through the somewhat atrophic epidermis; in some of these, rudimentary hairs could be observed, in others the papillæ were merely indicated. The cutis surrounding this region was changed into a coarse areolar tissue interspersed with granules and fat cells.

The *prognosis* in the universal congenital alopecia is said to be not as bad as in the partial affection.

Treatment can only be hygienic, and is limited to aiding the general nutrition processes.

2. ALOPECIA SENILIS; *Calvities Senilis.*—With the advent of old age, a loss of hair not only of the scalp, but also of the eybrows, the genital and the bearded region is observed. Women are not as extensively affected as men. While it is true that at the decline of human life an increase in the growth of hair is often seen, it is equally true that this growth never takes place upon the scalp.

As a rule the hair becomes gray before there is any sign of senile baldness, which begins upon the top of the vertex, at its junction with the occiput. The coarse hairs begin to fall out, at first from a small circular area only; this loss of hair spreads at the periphery, presenting a picture like the full moon shining through the clouds, and later on assuming the form of the tonsure of a friar. The disease spreads forward along the vertex, and descends laterally upon the temples and the region above the ears, and finally also invades the occiput. As a rule, it leaves a small rim of normal hair encircling the lower lateral and posterior parts of the scalp. The coarse hairs are replaced by lanugo hairs, but these also finally drop out. The scalp is then left as a smooth, shining surface, thinner and tenser than before, but still freely movable over the cranium. The mouths of the follicles may still be seen for some time, but they too shortly disappear

Pathological Anatomy.—The whole process is incidental to the retrogressive nutrition changes of senility. The prime factor is an obliterating endarteritis, which here means occlusion, lack of blood supply, atrophy, and death of these structures.

Treatment.—From the pathology of this condition it is plain that treatment is of no avail in averting the loss of hair.

3. ALOPECIÆ PREMATURÆ.—(*a*) *Alopecia Presenilis.*—When the symptoms of the last-described malady appear in younger persons who do not show any other evidences of the degeneration of old age, it is called "alopecia presenilis." Its course and pathology are the same as in the senile form, and therapeutic efforts are as useless. The wearing of stiff headgear, such as derbys and silk hats, is considered by some as a cause of this affection. They argue not only that the hard brims impede the circulation, by pressure upon the blood-vessels encircling the scalp, but that on account of their tight fit the air from expiration becomes so deteriorated as to be obnoxious. This factor may be remembered when a case presents itself. Invigorating treatment, and the avoidance of injurious diet and habits, may in some degree retard the progress of the disease. Active cell metabolism should be encouraged.

(*b*) *Alopecia Pityrodes sive Alopecia Furfuracea Capillitii.*—Our reasons for placing this affection among the essential premature diseases of the hair causing baldness have already been given. Its true nature is by no means definitely settled, as shown by the various designations given to it, *e.g. seborrhœal eczema, inflammatory seborrhœa, seborrhœal dermatitis*, besides those that are now obsolete, as, *seborrhœa sicca*, and *oleosa capitis, acne oleosa*, and others. It is one of the most frequent causes of bald-

ness. It is not confined to any particular age, but still is oftenest seen in persons who are at the end of the second, or at the beginning of the third decade of life. Women suffer from it more frequently than men. Elliot gives the relative frequency of the disease in the two sexes to be as five women to four males. Michelson states that women are *not* as often attacked as men.

One of the first conditions noticed by a patient is an increased scaliness of the scalp commonly known as dandruff. Associated with this is an obstinate itching, and a sensation of burning heat. The pityriasis increases as the years go on, when the sufferer complains that more hairs than usual fall out when combing. A woman will soon notice that her braids grow thinner at the ends, and that hairs commence to project from them. This phenomenon is due to the fact that the life duration of the individual hairs (a duration which, normally, is about four years) has become less than normal; therefore they do not attain the usual length.

The hairs taking the place of the shorter-lived ones grow, in the course of time, not only smaller, but also thinner. They lose their lustre and natural curliness, and finally are replaced only by lanugo hairs. An associated senile alopecia may hasten their disappearance. During all this time the dandruff increases in quantity, but at the appearance of the lanugo condition it stops suddenly, as if the disease had spent its energy. The pityriasis consists of whitish scales made up of epithelium, sebaceous matter, and dirt. According to the proportion of sebum in them, they may feel greasy or comparatively dry. The amount of dandruff is a good indication of the severity of the disease.

In addition to the sensations of itching, and heat, and headache, there is now experienced a feeling of tension all over the scalp. Michelson has observed increased perspiration in some cases at this period.

Although, strictly speaking, the loss of hair begins simultaneously over the whole scalp (Pincus, Michelson), there are certain areas that are more rapidly and more intensely invaded than others. As a rule, there are two principal centres of development, and both lie in the median line of the top of the head; the anterior one begins about one-half inch behind the border of the hair, and runs backward; the other one starts from the junction of the vertex and occiput, and progresses forward, so that there remains a bridge of hair between, which connects both parietal regions, and still remains even when the disease is far advanced; but it also finally breaks down. The occiput and lateral portions of the hairy scalp are not seriously attacked. The small bunch of hair in front of the anterior bald spot is also quite persistent. The anterior temporal regions, "the corners of the hair," may form two additional starting points.

Pathological Anatomy.—According to the description given by Pincus the epidermis is not thickened but made rather thinner than normal. Elliot (Morrow's "System of Genito-Urinary Diseases, Syphilis and Dermatology," vol. iii., 1894) has found processes of vacuolation in the epidermic cells, and infiltration with "Wanderzellen." The granular layer was seen to be slightly increased. The subcutis is the seat of marked inflammatory changes, as shown in the dense, small, round-cell infiltration which is arranged especially around the blood-vessels, particularly around those supplying the hair follicles and their papillæ. The hairs in themselves show nothing characteristic. They differ in no way from those that have undergone the process of physiological death, except that, in some instances the roots are smaller, atrophied, and have pointed ends, instead of showing the hollowed-out knob of the healthy hair. Increased brittleness may also be observed; but this probably occurs only in bad cases, and then only in the advanced stages of the disease. Later on, as evidences of a chronic inflammation make their appearance, the small round-cell infiltration is replaced by a dense network of fibrous tissue, which gives the feeling of tightness to the scalp, and prevents its being lifted up between the fingers. The subcutaneous fat is greatly increased in quantity.

Etiology.—Some diseases, such as syphilis, diabetes, typhoid fever, etc., are predisposing factors. French writers consider "arthritisme" as an important cause. Heredity also plays quite a rôle here. Any condition or malady that leaves the system in a weakened state must naturally be looked upon as furnishing a favorable chance for the invasion of the disease. Bad hygienic surroundings, defective cell metabolism, neglect of proper care of the scalp, general malnutrition, increased ingestion of sugars, loss of sleep—all of these have to be looked upon as probable predisposing factors. How really sensitive the hairs of the scalp are, is shown by the loss of their healthy lustre and oiliness after a single protracted dissipation, with its attendant loss of sleep and subsequent general depression.

Numerous are the organisms described by those who have attempted to verify the parasitic nature of the disease. Malassez considered his flask-shaped bacillus (called by Sabouraud "bacillus asciformis") as the cause of alopecia pityrodes. Unna holds that alopecia pityrodes is identical with his eczema seborrhoicum, and is caused by the morrococcus or mulberry coccus. Merrill, in connection with Elliot, has found a diplococcus with sufficient frequency to be able to attach to it some etiological importance (*New York Medical Journal*, 1895, vol. lxii). Sabouraud (*Annales de l'institut Pasteur*, 1897, and *Annales de derm. et de syph.*, 1897), after some painstaking experiments, believes that he has established the identity of some follicular affections hitherto regarded as separate diseases—*i.e.*, comedones, acne, seborrhœa, alopecia pityrodes, alopecia senilis, and alopecia areata. He describes a punctiform bacillus almost resembling a coccus, 1 μ in length and 0.5 μ in diameter. It has the power of penetrating deeply into the hair follicles and into the sebaceous glands, while, according to him, the flask-shaped bacillus of Malassez is confined to the funnel-shaped enlargement of the mouths of the diseased follicles. He sums up his explanation of the pathogenesis of alopecia pityrodes by stating that the presence of the micro-organism described by him first causes an irritation, and thus a hypersecretion of the sebaceous glands; then there follows a hypertrophy, and by further invasion, a progressive papillary atrophy, with malnutrition and atrophy of the hair-producing cells, hence death of the hairs that are formed, and cessation of the growth of new ones.

Right here it would seem appropriate to mention the fact that the parasitic theory of alopecia pityrodes was first advanced by Lassar and Bishop (*Monatshefte für praktische Dermatologie*, vol. i., 1882) after some experiments in which alopecia followed the inunction of a mixture of vaseline and finely cut hairs, taken from a typical case of this disease. In the case just mentioned alopecia appeared in the third week, and could be transmitted from the first series of animals to others. Michelson remarks that he was able to produce the same effects with rancid olive oil.

Saalfeld (Virchow's *Archiv*, 1899, vol. clvii.), repeated the experiments of Lassar and the bacteriological studies of Unna and Sabouraud. He was able, like Lassar, to produce a loss of hair, but not a typical alopecia pityrodes. He also succeeded in producing the same conditions with simple non-rancid oil, and even with the somewhat vigorous strokes of a brush. Using rancid oil, he obtained the same effects as Michelson. He has found micro-organisms which may be considered identical with those of Unna and Sabouraud, but he looks upon them as incidental. He was unsuccessful in proving that they produced alopecia pityrodes.

Diagnosis.—The disease may be readily recognized by its occupying usually the median portion of the scalp, the lateral and posterior parts being comparatively free, from the furfuraceous scales always present, in greater or less quantities, and from the sensations of itching and heat.

It is distinguished from senile, and more especially from presenile alopecia, in that these two forms begin upon the vertex of the head, while the anterior portions

enough cement substance to hold the individual cells together. The lower parts of the hairs show an increase in nuclei and pigment.

Besides the local treatment, which consists of invigorating baths, as for instance those of salt water, and that special treatment described under the local form of this affection, particular attention is to be directed to the general nutrition, which must be improved.

Alopecia Simplex.—Pincus has described instances in which there is a general loss of hair of the scalp; the crop of hair becomes thinner and thinner, just as it does in alopecia pityrodes, but there is no pityriasis in connection with the loss of hair. This latter fact made it seem proper to give this special form of the disease a separate name. The treatment is similar to that in alopecia pityrodes, only the shampooing to remove dandruff may be omitted as unnecessary.

(*c*) *Alopecia Areata.*—(Synonyms: Area celsi, area circumscripta, area accidentalis, tinea decalvans, teigne pelade, pelade.)

The term "alopecia areata," as it is used to-day, is rather vague and ill defined. Several diseases are probably included under it.

The affection is a disease of the hairy parts of the body, producing a loss of hair in circumscribed areas, which commence as small spots and gradually increase at the periphery, the underlying skin being apparently little or not at all affected. The regions most frequently attacked are the scalp, the beard, and the eyebrows. The disease may occur on any part of the body where hair is found. The loss of hair may be partial or complete. The mild cases are usually limited to the head, beard, and eyebrows.

FIG. 89.—Alopecia Areata. (From a photograph of one of author's cases.)

Crocker, in order to substantiate his belief in a connection between alopecia areata and ringworm, has pointed out that it is more frequent in those countries where the latter prevails (France and England), while both affections are far less frequent in Germany and America. Men are more often attacked than women, persons between the ages of ten and twenty-one more frequently than others; dark-haired persons suffer more from the affection than blondes.

Constitutional or local prodromal symptoms are absent as a rule; there may be some malaise, loss of appetite, headache, slight itching, and other paræsthesiæ. H. Schultze (Virchow's *Archiv*, vol. lxxx., 1880), who observed the disease on himself, made note in his case of a unilateral headache upon that side, which, later on, became invaded by alopecia areata.

The parts of the scalp most generally affected are those surrounding the junction of the occiput and the parietal bones. There is no symmetry in the lesions as a rule. The formation of the individual patches is about as follows: A patient may notice that in a certain spot his hair comes out very freely. He observes a bald space. He attempts to pull out some hairs, and finds that they can be removed very easily and wholly without pain. Afterward the hairs may fall out spontaneously along the periphery of the small patch first seen. The patch grows larger, rapidly or slowly, and in all directions. The increase in size may progress more rapidly in one direction than in another, thus creating oval or iregular patches. There may be only one patch, or there may be several, beginning at the same time, or, as is usually the case, there may be successive crops of bald spots.

The areas of baldness are from one-half to two inches in size, but by the coalescence of several areas very large patches are sometimes formed. Individual areas are not always very sharply defined from the surrounding healthy structures, in the first stages of the malady. The periphery is surrounded for a short distance by a thinner crop of hair. There may be some few healthy hairs left even in the centres of the bald areas, hairs which cling to their papillæ. Some broken-off hairs, projecting from their follicles, are often noticed upon close inspection. The skin at the seat of the affection is smooth, shiny, thin, and can readily be lifted up between the fingers. It looks paler than the normal skin, and on being pricked with a needle blood oozes less readily. There are no vesicles, crusts, or scales, no efflorescences of any kind. In some few cases I have observed a slight scaling, redness, and some œdema at the beginning of the disease. The level of the affected skin is felt to be below that of the neighboring normal skin. This is due to the fact that the skin has sunken in, on account of the absence of so many hairs in the now collapsed hair follicles, and not, as some believe, to an atrophy of the cutis. The nervous impressions are not impaired. The tactile, temperature, and pressure senses may be slightly increased (Michelson). Neumann, however, has observed anæsthesia. When the disease, at a given patch, has come to a standstill, the hairs at the periphery become more normal in number, and cannot be as easily plucked out as before; the affected area is now sharply defined. The period of baldness of such a patch is, as a rule, of several weeks' duration, and if, at the expiration of this time, there are no signs of regeneration, it is difficult to determine when the hairs will make their reappearance. The malady may go on for years and years. Recovery has been observed after a period of from ten to fourteen years, and even after a much longer time; it may, however, never take place.

Reproduction of healthy hair begins almost always at the periphery and progresses from without inward. First, small lanugo hairs begin to appear. These, after a short struggle for existence, may fall out again, to be replaced by stronger and longer hairs. This replacement of the new hairs by others may repeat itself several times before the normal hairs finally make their appearance, and these latter may even then lack color for a long time.

The affected area may long after be recognized as the site of a previous alopecia areata.

Alopecia areata of the other hairy regions presents analogous phenomena. The beard, eyebrows, axillary and pubic hairs may fall out. All the hairs of the body may disappear, thus constituting the alopecia maligna of Michelson.

Pathology.—Nothing characteristic of this affection can be obtained from an examination of the hairs. They show the same simple atrophy as seen in the hairs shed in the physiological way. In some the roots are not bulb-shaped, but pointed, a fact to which we have already called attention, in connection with the pathology of alopecia pityrodes.

I have given my observations of the microscopical changes of the skin before the Ninth International Medical Congress at Washington (1887). Many pieces of skin were taken from seven different patients. In spite of the clinical appearance of the disease, the presence of an inflammatory process in every case could be observed. S. Giovannini (*Ann. de derm. et de syph.*, 1891) and Sabouraud (*ibid.*, 1896) have also found perivascular small round-cell infiltration, consisting of "Mastzellen" and mononuclear leucocytes. This, according to Sabouraud, goes to show the presence of an agent with decided chemotactic influences upon these cells, an agent probably emanating from a micro-organism. In my sections, the subcutaneous tissue was normal, the lymphatics were somewhat dilated and contained micrococci. Whether they have any etiological relationship to the pathological phenomena, I have so far been unable to demonstrate.

Some hair follicles showed replacement of the normal hair by lanugo. The hairs in some were broken, or stubbed and split. The lower parts of the follicles were devoid of pigment, this explaining the loss of color of the returning hairs during convalescence. In cases of permanent alopecia of long standing, hair follicles and sebaceous glands had been destroyed. The blood-vessels showed a thickening of their walls.

Etiology.—There is in dermatology hardly a single disease whose nature is so much disputed as that of alopecia areata. Three views are held in regard to it: first, that it is a trophoneurosis; second, that it is of parasitic origin; third, that what we understand under alopecia areata to-day is not a clinical entity at all, but that under this name are grouped several diseases, some of which are neurotic, while others are parasitic. Truth, I believe, rests with those who uphold the last-named theory.

In my opinion, every case of alopecia that commences as a small spot and gradually increases in area by extension at the periphery and shows the clinical characters I have described, is due to the local action of an organism.

In support of the first view are cited the nervous prodromal symptoms, such as neuralgia, headache, and the various paræsthesiæ, and the fact that loss of hair in patches often follows nerve injuries. Kaposi enumerates many instances of this kind. Best known are the experiments of Joseph and Mibelli, who observed alopecia following the excision of the second cervical ganglion. Moskalenko and Ter-Gregoryanitz (*Vrach.*, 1899) have produced typical alopecia areata in dogs, cats, and rabbits by performing the same operation, and also by cutting the nerve roots. Injury to the peripheral nerves produced no typical alopecia areata, as the patches that showed themselves were not round. If the disease were always due to nerve injuries, the triangular form, corresponding to the area of supply of a given nerve, should be more frequent. Besides, there are undoubted cases in which the lesions spread without regard to blood-vessel or nerve supply.

According to my view of the subject, the cases of circumscribed loss of hair following nerve injuries are not instances of alopecia areata, if we understand this term to mean an affection in which the hair falls out in round patches, which spread at the periphery; this being always the true progress of a parasitic disease.

The fact that regeneration progresses from without inward has been brought forward as an argument against the theory; if justly so, remains to be seen. Another argument against it is the absence of all inflammatory symptoms usually seen upon the surface—*i.e.*, vesicles, scales, crusts, etc.; but as already mentioned, an inflammatory process is always present.

Numerous organisms have been found. As early as 1843, Gruby had described his "Microsporon Audouini," but it was found that it represented one of the forms of the ringworm fungus. Others who called attention to parasites are Malassez (1875), Thin (1881, bacterium decalvans), von Sehlen (1884, areacoccus), myself (1887), and Vaillard, Vincent, Nimier (1889), etc. In 1896 Sabouraud (*Ann. derm. et syph.*, 1896, i.) brought to notice an organism which he named "microbacillus alopeciæ areatæ," and, not being certain as to its etiological importance, "le microbacille de l'utricle peladique." He admits that it may be identical with Unna's and Hodam's organism found in comedones, and in acne. In the following year (1897, *Annales de l'institut Pasteur*) he stated that in his opinion comedones, acne, seborrhœa, alopecia pityrodes, and alopecia areata are all caused by the same organism, varying only in intensity and location.

In support of the parasitic theory, frequent reference is made to the instances of contagion as cited by Crocker, many French authorities, and by Bowen and Putnam of this country (*Journ. of Cut. and Genito-Urinary Diseases*, 1897,) and again by Bowen in 1899, in the same journal. In France the disease has been observed especially in the army, and is believed to have been due to having used the same hair-clipping machines, or to having worn the same caps and helmets. Sabouraud (*loc. cit.*) has observed that many cases applying for treatment at the Hôpital St. Louis came from the same section of the town, and that some had employed the same hairdresser. The epidemic in an asylum, described by Putnam, is remarkable. Sixty-three out of sixty-nine girls were infected, and there was no trace of ringworm. A girl, who was believed to have spread the disease, left the institution, and went home, where in a short time her stepfather became infected. In the mean time the epidemic at the asylum had come to a standstill. A few years after, this same girl was again received at the institution, and in a very short time twenty-six out of forty-five children showed evidences of the disease. Hutchinson and Crocker think that there is some relationship between ringworm and alopecia areata.

Diagnosis.—A typical case can be readily recognized by the lesions being round and spreading at the periphery. The thin, smooth, shiny skin, sunken beneath the niveau of the surrounding healthy skin, and showing no signs of an inflammatory process, makes the diagnosis easy. Alopecia areata has to be differentiated from ringworm, favus, sycosis, syphilis, folliculitis decalvans, and the loss of hair after traumatism. Alopecia maligna must be distinguished from alopecia pityrodes universalis (*vide* above).

In ringworm we find dermatitis, broken-off hairs, and the ringworm fungus under the microscope; in favus, also, the organism producing it, as well as the yellow cups, scar tissue, and a grayish discoloration of the atrophied hairs. Folliculitis decalvans presents evidences of follicular inflammation and scar-tissue formation. Alopecia syphilitica shows irregular patches, not depressed, especially affecting the outer portions of the scalp and the eyebrows; besides these, there are concomitant symptoms of the disease.

Cases of the falling out of hair in patches, in consequence of nerve injuries, have been observed, and the characteristics of the resulting bald spots were similar to those of the ordinary cases of alopecia areata. The clinical history of the manner of formation of the patch is, however, different. I consider those cases only to be true examples of alopecia areata in which the patches grow by extension at the periphery.

Prognosis.—As alopecia areata tends to a spontaneous recovery in the majority of cases the prognosis is favor-

able. Even if regeneration does not show itself for years, hope should not be entirely abandoned, for regeneration may ultimately take place. This was true in several instances, where new hairs grew even after a decade or more from the beginning of the malady. It is my experience, however, that if a patch remains quite free from lanugo hairs for several months, it shows that the follicles are probably destroyed and that there will be a permanent alopecia. The older the patient, and the longer the area has been affected, the graver becomes the outlook as to recovery. The possibility of relapses must not be forgotten.

Treatment.—On account of the fact that recovery is often spontaneous, it is exceedingly difficult to appreciate the value of any therapeutic agent otherwise than by means of a long series of observations. A host of remedies has been recommended. Internally, arsenic, cod-liver oil, tonics, and jaborandi should be tried in connection with dieting, physical and mental hygiene. While such a therapy may not have any direct effect upon the cause of the lesions, it may help to render the system more resistant to the disease. Tinctura jaborandi is administered to produce a local hyperæmia of the pale patches whose blood-vessels are abnormally contracted.

The older methods of local treatment were addressed to stimulate the nutritive processes of the part; to-day, when the parasitic theory prevails, parasiticides are used. Chrysarobin, in my opinion, stands out far above any other remedy. It is most effectual when incorporated in vaselin or lanolin; much more so than when combined with liquor gutta percha or traumaticin. As a rule, a six to ten per-cent. preparation is applied daily for one or two weeks, and then stopped for a short time to observe if the disease has stopped. If lanugo hairs do not appear soon, or if the hairs at the periphery continue to fall out or can be easily pulled out, the treatment is continued. Care should be taken that the application does not reach the eyes, as a severe conjunctivitis might follow. Because of this possible danger it cannot be used upon the eyebrows. Jessner (*Monatshefte f. prakt. Derm.*, 1900) recommends for these that carbolic acid be applied bi-weekly. The slight mahogany discoloration observed around the neck and in the face, after the use of chrysarobin, is the first danger signal of an approaching dermatitis. The remedy should now either be stopped at once, or the strength of the ointment be reduced. The hairs around the periphery should be removed as soon as they become loose. Croton oil, which is a pure irritant, may be of benefit in chronic cases. It should be used with olive oil, equal parts, and applied every day until a dermatitis is produced.

Balzer and Storianowitch (*Journ. des practiciens*, 1899; *Monatsschrift f. prakt. Derm.*, 1900) have obtained good results with a fifty-per-cent. solution of lactic acid in water or alcohol. The affected parts are first freed from oil with alcohol and ether, and the remedy is then applied with a swab of cotton until slight redness appears. Besides this the scalp is washed with a one-per-cent. bichloride solution. After the stimulation has become well marked, the applications of lactic acid are interrupted for a few days. Boric acid vaseline is spread upon the surface in the intervals. The alcoholic solution is said to be the less painful.

Recovery was obtained fifteen times out of nineteen cases, in from two to three and a half months. Lanugo hairs made their appearance at the end of the second week, at the earliest. McGowan (*Journ. of Cut. and Genito-Urinary Diseases*, 1899) recommends trikresol used pure upon the scalp, and upon the face in a fifty-per-cent. solution. He was led to use this remedy from his experience with pure carbolic acid.

Scarification, with subsequent application of a solution of corrosive sublimate 1:2,000, as in erysipelas, seems to be a rational mode of treatment, but still there is some danger here of infection with pus organisms. Injections of bichloride 1:40, made at different points, are recommended by Moty, of Paris.

Lately, Finsen, of Copenhagen, who obtained such brilliant results, especially in lupus vulgaris, with the application of concentrated violet light rays, has been successful in treating alopecia areata by the same method (*British Medical Journal*, 1899). Jesild (*Annales de derm. et de syph.*, 1899), who has followed Finsen in his treatment, states that it cures alopecia areata in two months, instead of the three to six months necessary by the use of older methods.

Brisquet uses oil of cinnamon (Chinese) and sulphurous ether 1:3. He avoids washing the scalp to exclude humidity (after the hairs have ceased to fall). The sulphur preparations are often of prompt and decided value; *e.g.*, an ointment of one to two drachms of precipitated sulphur to an ounce of vaseline, rubbed well into the scalp daily, after a thorough washing of the whole scalp with soap and water.

In my opinion, as already stated, cures can be obtained more quickly, and with greater certainty, from the use of chrysarobin than by any other method. After the hairs have ceased to fall out, some stimulating and antiparasitic application should be applied for a few months.

(*d*) *Folliculitis Decalvans.*—Within the last decade French authors especially have called attention to the hair follicles being attacked by some affection whose nature still remains obscure. Each authority in turn has considered the individual disease before him as a new one, and has stamped it with a new name, so that in wading through their literature, we meet with a formidable array of names, "the sum of which has brought despair to every humble reader" (*vide* my article in Morrow's "System of Genito-Urinary Diseases, Syphilis and Dermatology, 1894). Some of these affections are identical, some represent only novel aspects of well-known diseases.

The following are a few of the titles given: "Folliculites et perifolliculites agminées destructives du follicle pileux" (Brocq); "folliculite épilante" (Quinquaud); "folliculites et perifolliculites décalvantes agminées (Brocq); "alopécie cicatricielle innominée" (Besnier); "acné dépilante cicatricielle" (Besnier); "acné décalvante" (Besnier, Lailler, Robert); "lupoid sycosis" (Milton, Brocq); "ulerythma sycosiforme" (Unna).

A description of a few of these types may suffice.

(*a*) "*Pseudo-Pelade*," *Simple Folliculitis Decalvans.*—This affection somewhat resembles alopecia areata, but on close inspection a mild folliculitis and perifolliculitis may be noticed. There are rose-colored, inflammatory tumefactions, soft to the touch; the hairs fall out, and are easily plucked out; they are not broken; there is a marked atrophy in the older spots; these are depressed, shiny, and, unlike those of alopecia areata, hard and irregular, and, as a rule, smaller. The disease spreads in an irregular manner.

(*β*) "*Folliculite Épilante*" *of Quinquaud.*—This form corresponds to the acné décalvante of Lailler and Robert. It resembles the former with the addition of suppuration in the follicles. Besides the scalp, the beard, axillæ, and pubic regions may be involved. Permanent alopecia appears also, caused by the cicatricial destruction of the hair-producing areas. The bald spots are round or irregular; along "their periphery or in islands of healthy hair within them, small pustules, perforated with a hair, are usually to be seen." Quinquaud found micrococci, but was unable to establish their causative effect.

(*γ*) "*Alopécie cicatricielle innominée*" of Besnier is almost identical with Quinquaud's disease. It is slightly more superficial, more chronic, and more obstinate; the cicatricial changes are greater; the margins are not sharply defined; the disease spreads by continuity. Besnier himself considered both diseases the same, but Quinquaud stated that they are not identical.

(*e*) "*Dermatitis Papillaris Capillitii.*"—Under this name Kaposi has described a follicular disease appearing at the junction of the nape of the neck and the scalp, invading the latter often as far as the vertex. It is doubtful whether this affection is a clinical entity, or simply a variety of some other disease. According to

This is a saline sulphureted water of considerable potency. It has been used with favorable results in cases of rheumatism, syphilis, neurasthenia, dyspepsia, Bright's disease, and certain skin affections, notably eczema, psoriasis, and lichen. The internal use of the water has been found advantageous in constipation, diabetes, and vesical catarrh.

Alpena now contains a population of 17,000 or 18,000. It is in all respects a city of progress, and contains all the advantages of the recent inventions in electricity, as well as gas, water-works, etc. *J. K. Crook.*

ALPS.—The extensive and lofty group of mountains occupying the central region of Europe, in Switzerland, Savoy, Southern Bavaria, and Western Austria, and separating Italy from the colder countries which lie to the north of it, presents to the invalid a great variety of places of resort, some chiefly serviceable during the summer months, some during the winter season, and some of them available as sanitaria at all times of the year. For a discussion of the peculiar properties and advantages of the more elevated of these health stations, see article on *Altitudes, High*; for description of the special features of individual stations of the more truly Alpine class, see *Davos, Wiesen, St. Moritz,* etc.; for accounts of individual resorts lying on a lower level than those just mentioned, see *Vevey, Meran, Montreux,* etc.

H. R.

ALTERATIVES.—An alterative is a term applied to a group of remedies which exert a very decided action in removing morbid conditions of the system, and improving the patient's general well-being. The term was formerly understood to mean a remedy which "would re-establish the healthy functions of the animal economy, without producing any sensible evacuation." Modern advance in physiology and therapeutics, and the recognized importance of excretion as a factor in promoting health, require a change in this definition, and our interpretation of the term is better expressed as "agents which alter the course of morbid conditions, and modify the nutritive processes while promoting waste." By many the use of the term is frowned upon, and it is described as a cloak to hide ignorance, but its employment will be continued until we possess a much greater knowledge of the action of such drugs.

We are unable to explain the action of this class of remedies, and their employment is entirely empirical. Their therapeutic value, however, is assured. We are certain of the effect of mercury or of the iodides in syphilitic affections, and of arsenic in improving the general health; but we cannot say how the result is effected, or why one is beneficial in one condition, and the other in another. Until we know how the disease affects the system we cannot explain the cure. At present we must picture the tissues as being constructed of inferior material. We must see them impregnated with syphilitic, malarial, or other similar poisons, or depraved by retained excrementitious matter; if we can do this, we can readily understand how the alterative remedy counteracts and removes these poisons, the result being purer material and in consequence a healthier tissue.

The most important and best-known alteratives are mercury, iodine, and arsenic. We have also sulphur, antimony, gold, calcium chloride, potash, guaiacum, colchicum, and a host of others which are more or less correctly grouped under this comprehensive title.

These remedies are all active and require to be administered with care. They are rapidly absorbed and carried to the tissues, where they become intimately connected with the vital processes. Escaping with the products of metamorphosis, they are excreted by the various secreting surfaces. Their prolonged or excessive use proves injurious: they cause depression and weakness and often produce much irritation during their passage from the system, as in salivation.

Alteratives are often of more service when combined, as in the case of the iodide of mercury, or as in Donovan's solution—a combination of mercury, arsenic, and iodine. The addition of taraxicum and sarsaparilla to iodides and mercury, although of doubtful value, is very general, and with many practitioners the value of one is almost as great as that of the other. The combination of alteratives with tonics and hæmatinics is of great importance. Arsenic and iron, and iodide of iron, with or without vegetable bitters, are standard remedies.

To augment the value of alteratives, more active eliminants are indicated. In conditions of the system in which the products of malnutrition have accumulated, when the blood is anæmic, and the liver, bowels, and kidneys inactive, a course of salines preceding and accompanying the alterative will greatly increase its value; so also will the combination with colocynth, podophyllin, or rhubarb. The waste material must be removed before a new healthy growth begins, and the more actively this is carried on the more rapid will the improvement be.

In addition water must not be forgotten. It is nature's alterative. It bathes and washes all the tissues of the body, it assists at tissue growth and decay, and renders all the emunctories active. To it is due the great value of specific treatment at the various mineral springs and spas, when the free use of alterative drugs, with abundance of water and fresh air, rapidly restores the invalid to health and strength. *Beaumont Small.*

ALTITUDES, HIGH.—This term is usually applied to those places which are situated not less than 4,500 feet above sea level. While the effects of altitude are noticeable in a minor but increasing degree from 1,000 feet up, yet it has been found most convenient by climatologists arbitrarily to place the lower limits of high altitudes at 4,500 feet. The climates of the various resorts at high altitudes naturally vary on account of their proximity to the equator, to the ocean, and to mountain ranges, and moreover, they vary by reason of local peculiarities. They have, however, one climatic factor peculiar to themselves, and upon which depends for the most part their special therapeutic value, that is, diminished barometric pressure.

With respect to temperature the air is as a rule cooler than at places of low levels in the same latitude. It may be stated broadly that the temperature decreases one degree for every three to four hundred feet of elevation. This applies to the temperature in the shade and at night; the sun temperatures, however, are, as a rule, higher than at low level places of the same latitude, with the exception of certain desert countries.

The humidity of the air at high altitudes is usually less than at sea level, even when comparison is made with places which are situated an equal distance from the ocean.

There are, of course, exceptions during certain seasons and in most valleys and on mountain slopes upon which the clouds gather. The humidity is much less on the lee side than on the windward side of the range, which is exposed to the moisture-laden winds from the nearest ocean.

The precipitation is generally less at high altitudes, especially on the lee side of the mountain ranges and below the snow line. This is true also of the number of rainy and cloudy days.

The dew point is low and the evaporative power of the air great, so that while heavy storms are not infrequent, the air and ground become quickly dry. On account of this quality of dryness, a greater degree of temperature can be borne than at low levels without suffering, because the evaporation from the surface of the body is greater, and, therefore, as has been demonstrated by Professor Greely and others, the "sensible temperature" is less. Moreover, the cool nights give rest after hot days. It is probably because of the cool nights, cool shade, and dryness of the air that sunstroke is practically unknown in high climates, even when the solar temperatures are very high.

The sunlight is more brilliant, and the sun heat more intense.

The aspect, the vegetation, the nature of the soil, and the configuration of the ground all modify the climate. With regard to the configuration of the ground, lofty plateaux are drier and warmer, and generally more windy than mountain slopes and valleys.

Owing to the mountainous character of high altitudes, their comparative inaccessibility, and the scarcity of water, they are but sparsely inhabited, and the ground is but little cultivated; in consequence of this, there is an abundance of pure air; so that the climate of the altitudes resembles in this respect that of the ocean and of the desert.

The physiological effects of diminished barometric pressure are very striking. The most important is, first, the change in the condition of the blood, second, the increased respiratory capacity and activity, and third, the increase in the size and strength of the heart. Nerve power and activity in the healthy are also increased, while in certain classes of invalids, however, the nervous energy is markedly depressed or unduly excited. The blood changes referred to are a large increase in the number of red cells, which fact is now universally accepted by all observers, though the cause is still somewhat in dispute. Moreover, it has lately been proven that the size of the red cells is also increased. The hæmoglobin, specific gravity, and iron are all increased. While it is true that such changes as described may be brought about in a greater or less degree by certain of the climatic factors which high altitudes enjoy in common with other climates, yet they are invariably produced, except under a few abnormal conditions, in all animals and human beings when they are transferred from low to high altitudes, and as a general rule in proportion to the elevation above sea level. Moreover, that these universal changes are primarily produced by diminished barometric pressure, has been proven by numerous laboratory experiments, notably those of Paul Regnard.*

Professor Regnard, in his laboratory at the Sorbonne in Paris, placed a rabbit under a bell glass in which the air pressure was kept constantly reduced to an equivalent of the barometric pressure at an altitude of 9,500 feet. When cleaning and disinfecting were necessary, the rabbit was transferred to another bell glass in which the air pressure was the same. The rabbit continued to live under these conditions for a month, and when removed was somewhat fatter and in a healthy condition. On testing its blood before placing it in the bell jar, it was found that it could absorb only 17 c.c. of oxygen, which was the case with the blood of the control rabbits, and was normal for sea level. On removal of this rabbit its blood was found to absorb 21 c.c. of oxygen; thus proving that the increased capacity of the blood for the absorption of oxygen at high altitudes was primarily due to the diminution of the barometric pressure. Much work has been done by numerous eminent observers confirming this conclusion.

With regard to the question whether a true, or only an apparent blood regeneration occurs, this matter has, in the writer's opinion, been settled by the experiments of Drs. Ossian Schaumann and Emil Rosenquist, of Helsingfors, Finland,† who conducted their inquiries especially to solve this question. Rabbits, dogs, and pigeons were kept in bell jars at reduced barometric pressure (450–480 mm. Hg) according to the methods of Sellier, Regnard, and others, for periods varying from nine to thirty-three days.

The blood was examined in each case at intervals of several days. This examination consisted of (1) a count of the red cells (Thoma-Zeiss apparatus); (2) the estimation of hæmoglobin (Fleischl); (3) the measurement of the diameters of the red cells (these were dry preparations, and the average was based on 200 to 500 determinations); (4) microscopic examinations were made, especially to determine the number of nucleated red cells (Ehrlich's triacid stain; also eosin and hæmatoxylin were used). The blood was taken from the neck in the pigeons and from the ears of the rabbits and dogs. Blood from the liver and aorta was also examined in a few cases before the animal was killed. In two cases the gross changes in the marrow of the long bones were also observed.

In every case the number of red cells was increased from 20 to 50 per cent. As the relative humidity of the air in the bell jars stood at 87 to 100 per cent., the temperature at 21°–26° C., the increase could not have been due to an inspissation of the blood, as some observers have assumed.

The hæmoglobin was also markedly increased, but not in as great a proportion as the red cells. In all cases during the first eight to eleven days there was a temporary decrease in the hæmoglobin, and, in about one-half of the cases, a like temporary decrease in the number of red cells.

To determine the effect of a return to normal barometric pressure (760 mm.), after the animals were released from the bell jars, the experimenters continued to examine the blood for periods varying from three to ten months; these examinations showed that there was an immediate decrease in the number of red cells, followed by a marked rise, which, after a number of fluctuations, remained in almost all cases at a decidedly higher figure than that which was reached by the blood count previous to the experiment. In the opinion of these observers, the investigations of others had not demonstrated these facts because they were not extended over a sufficiently lengthy period. Leuch,* however, in his experiments on anæmic school children, confirms this point. Children were sent by him to the mountains for several weeks after their blood was tested, and the test was then repeated, on their return, from time to time, during periods of from two to four months.

Schaumann and Rosenquist, by exact measurement of the red cells, show that the average diameter of the cells is always increased, which is contrary to the opinion previously held. Under the low pressure the nucleated red cells slightly increased in number, but returned to the average amount after the normal air pressure was resumed.

In two animals confined in bell jars, and from two control animals the blood was simultaneously taken from the skin, liver, and aorta; and in each locality the number of red cells per cubic millimetre was found to be exactly the same.

With regard to Schaumann's and Rosenquist's views on the other theories of the cause of these blood changes, the following abstract of their opinions is valuable:

Two of these theories assume that the increase in red cells is real. Miescher, Egger, and others support the view of increased proliferation of blood cells in the blood-forming tissues, while Fick's theory is that there is a prolongation of the life of the individual cell along with a normal proliferation.

The other four hypotheses contend that the increase in red cells is only apparent. Thus, Grawitz considers it to be entirely due to an inspissation of the blood; while Bunge believes it to be the result of an exudation of plasma into the lymph spaces of the tissues.

Winternitz supposes that red cells become aggregated in certain of the internal organs, and are forced into the general circulation by changes produced upon the latter by altitude; and Zuntz finally refers it to vasomotor control, which is influenced by certain factors of high altitude.

In the light of the results of this investigation, the following criticisms of each theory are made. The authors consider that their results support the theory of new formation of blood cells, but are forced to make changes in the terms of its form.

Vaso-motor Theories.†—1. Zuntz's hypothesis: The authors point out that in their own experiments no factors exist which could give rise to the required nervous

* "La Cure d'Altitude," Masson et Cie., Paris, 1897.
† "Ueber die Natur d. Blutveränderungen i. Hohenklima." Zeitschr. f. klin. Med., Bd. xxxv., Heft 1-4, pp. 126, 170, and 315–349, 1898.

* Leuch: Correspondenzblatt f. Schweizer Aerzte, No. 21, p. 657, 1896.
† Schumburg u. Zuntz: Pflüge's Archiv f. Physiol., Bd. lxiii., pp. 461-494, 1896.

irritation, that their animals were removed from the bell jars for each examination, and that, according to the theory, the irritation should quickly disappear.

With reference to the theory that the number of red cells is increased in the capillaries and decreased in larger vessels, it is pointed out that in former investigations blood from both the capillaries and the larger vessels had been examined, with the uniform result of an increase in red cells; that the simultaneous increase in red cells and decrease in hæmoglobin (at the beginning of the experiments) cannot be explained by this theory. That a purely vasomotor change should produce no change in the size of the red cells; that the overstimulated nerves would eventually relax; that a return to higher pressure should produce an immediate fall in the number of red cells to normal, which is not the case.

2. Bunge's theory * is met with the same objections.

3. Winternitz's theory † the authors oppose by reference to their examination in two cases of blood taken simultaneously from the skin, liver, and aorta, in each of which localities they found the same count. (Corroborated by Breitrustrin.)

4. Grawitz's theory of inspissation: ‡ This theory is invalidated by the experiments of Schaumann and Rosenquist in which the respired air was almost saturated with water vapor; by the fact that loss of water by the blood is rapidly compensated for by the tissue fluids, and that a true inspissation of the blood is always accompanied by a proportionate loss in weight of the animal; and, further, by the fact that in true inspissation of the blood the diameter of the red cells is always decreased.

FIG. 90.—Kurhaus on the Little Scheidegg, at the Foot of the Eiger. Elevation, 6,770 feet. (From Regnard's "Cure d'Altitude.")

Theories Assuming a True Increase in Red Cells.—1. Fick's theory: § This theory, which premises that the absorption of oxygen is slower than normal at high altitudes and the consumption of hæmoglobin is decreased, is discredited because it has been conclusively shown that metabolism is more rapid at high altitudes than at sea level, and must, therefore, especially increase the consumption of hæmoglobin.

2. The theory of regeneration of Miescher, Egger,‖ and others is based on the two premises (1) that microcytes appear during the period of increase in red cells, and (2) that the increase in hæmoglobin does not keep pace with that in the number of red cells. The last point the authors grant, and they call attention to the fact that it has been regarded generally (Otto, Hoffmann, and Limbeck) as an evidence of regeneration. The first assumption is disputed, and attention is called to the fact that Ehrlich, Quincke and von Limbeck look upon microcytes as products of degeneration of red cells, and also that one of the authors (Schaumann) has found in secondary anæmias that microcytes are most numerous at the height of the disease, and that they disappear as convalescence sets in, and give place to macrocytes. To determine this point experimentally, two animals (a rabbit and a dog) were bled, and a differential count was made of red cells of various diameters, with the result that microcytes were seen to diminish markedly in number immediately after the bleeding when regeneration is most active. It was found, moreover, that an increase occurred in the number of macrocytes, and that this, instead of an increase in microcytes, is an accompaniment of regeneration. In accordance with this finding, it follows that the increase in macrocytes met with in the blood in the author's first experiments indicates a regeneration of red cells. This conclusion is strengthened by the occurrence of nucleated red cells in the mammals, of mitotic figures in the red cells of the birds employed, and of "shell shadows" in the blood after release from the bell jar.

Schaumann and Rosenquist, therefore, conclude that all changes which occur in the blood, due to diminution of barometric pressure, are best and most easily explained by the assumption that there is an increased proliferation of red cells.

The authors claim that this theory holds also for the explanation of the results of the *clinical* observations made in high altitudes. They reach this conclusion by a process of elimination, having shown in their criticism of the other theories that causes other than a diminution of atmospheric pressure are insufficient for the production of the hæmatic phenomena. As positive proofs from clinical material, they refer to the following: The hæmoglobin does not increase in proportion to the increase in the number of red cells; the increase in the average diameter of red cells, and the presence of normoblast nuclei found free in the blood. (The last two points are dependent on the findings in the blood on Schaumann's journey to Norway.)

Experiments are needed to prove whether or no the germicidal power of the blood is increased. Clinical and other evidence makes it most probable that this is the case.

"At high altitudes the special effects of decreased pressure are not directly produced by the scarcity of oxygen in the atmosphere, but by the diminished oxygen pressure; for even at the greatest heights ever reached by man the amount of oxygen in each breath is always in excess of that needed to sustain animal life. It has

* Bunge: Verhandlungen d. 13 Cong. f. inn. Med., 1895.

† Winternitz: Centralbl. f. klin. Med., Bd. xiv., No. 49, pp. 1017-1022, 1893.

‡ Grawitz, E.: "Klin. Pathologie d. Blutes," pp. 333-343, Berlin, 1896. Limbeck, R. v.: "Klin. Pathol. d. Blutes," 2 Aufl., p. 207, Jena, 1896. Ehrlich: "Untersuchungen z. Histol. u. Klinik d. Blutes," p. 99, Berlin, 1891. Quincke: Deutsch. Arch. f. klin. Med., Bd. xx., pp. 1-31, 1877.

§ Fick, A.: Pflüger's Arch. f. Physiol., Bd. ix., pp. 589-593.

‖ Miescher: Correspondenzbl. f. Schweizer Aerzte, pp. 809-832, 1893. Egger: Verhandlungen d. 12 Cong. f. inn. Med., pp. 262-276, 1893.

Altitudes.

been demonstrated by experiment that blood can absorb only a certain percentage of the total amount of oxygen present in the air to which it is exposed, and so, when the barometric pressure is reduced, the blood may be unable to extract sufficient oxygen from the air, because the oxygen pressure is reduced below the required point.

"Mountain sickness is a malady caused by this oxygen starvation. If this were all, it would follow that when the oxygen pressure was sufficiently reduced animal life would be impossible from continual mountain sickness; but there is developed a wonderful compensatory process whereby the blood's power of absorbing oxygen is increased, so that a given weight of blood in a living animal can absorb more oxygen in proportion to the reduction of the barometric pressure. This is brought about by a growth in the number of red corpuscles through which oxygen is absorbed.

"While these blood changes, which need some three or four weeks for their completion, are progressing, the breathing becomes more rapid, so that while less oxygen is taken in at each breath, it is received into the blood more frequently; and with this more rapid respiration there is increased heart action, the heart pumping more blood through the lungs in a given space of time.

"This increased rapidity of heart beat and respiration is, however, only temporary, and gradually disappears. The amount of air taken in at each breath increases in volume as the chest expands, and the air cells, many of which, at lower altitudes, are often unused, become enlarged. The heart's cavities, having been stretched, are also hypertrophied, so that more blood is propelled at each stroke. Thus the blood's capacity for absorbing oxygen, the lung's capacity for taking air, and the heart's capacity for pumping blood are increased; the rapidity of respiration and pulse diminishes, but this rate becomes normal again as soon as this process of compensation has effected a balance.

"These changes in the blood, lungs, and heart continue during a residence at high altitudes, but disappear again upon a return to low ground. However, they are occasionally so incompletely carried out in certain individuals, owing to age, feebleness of reaction, or disease, that an attempted ascent into the upper air is exceedingly dangerous and continued residence on high ground impossible."*

There are striking differences between the temporary and the permanent physiological effects of high altitudes. When persons or animals are transported from low levels to a high altitude, the influence is marked in proportion to the rapidity of the ascent, as is shown by the contrast in the effects produced upon those who ascend rapidly, and upon those who are slowly carried up by rail or carriage. In mountain climbing the effects are increased by exertion. The more vigorous and healthy the individual submitted to these experiences, the more rapid and complete is the acclimatization. Speaking broadly, the acclimatizing continues through the first four weeks, after which time a healthy visitor can do about the same amount of work on level ground, and feel as well, as he did at home; at least until he attempts to climb still higher, when the symptoms of mountain sickness will again occur, but in a modified form.

In the various experiments and observations that have been made upon the ability of a healthy man to undertake muscular exertion in high altitudes, it has been found that visitors, after the first few weeks, can usually accomplish as much within a short space of time as on low ground, but they are not equal to as prolonged exertion, and their pulse rate and respiration are always increased above what it would be at sea level under like circumstances. It is, therefore, important for invalids and even for healthy visitors, on first resorting to high altitudes, that they reduce their accustomed exercise to at least one-half of that which agreed with them at sea level; particularly on going uphill.

With respect to our knowledge of the permanent effects of high altitudes, we are especially indebted to Drs. Herrera and Lope of the City of Mexico, who have, in their very valuable treatise entitled, "La Vie sur les Hauts Plateaux," given us a vast amount of information. One of the results of their laborious and conscientious scientific inquiries is that plants, animals, and human beings soon accommodate themselves to the peculiar conditions of life at high altitudes, and that healthy residents and natives thrive. The portion of their inquiries which is especially interesting to the therapeutist is that there is a marked development of the thorax, and that even under unfavorable local hygienic conditions, the average rate of morbidity and mortality is lower than under the same conditions at sea level. In short, for those who have acquired or inherited accommodation to the peculiar conditions, there is a more than usual amount of health and physical prosperity.

While, physiologically, all these changes of the blood, lungs, and heart are simply compensatory, yet to the properly selected invalid they are much more, because they give a stimulus and open up avenues through which health returns, and the changes in an appropriate invalid are even greater than they are in a normal being. For instance, in an anæmic person the blood changes are proportionately in excess, and this is true not only when they are in the high altitude, but also when they return to their home at sea level.

The nervous depression and anæmia accompanying most cases of neurasthenia are markedly and rapidly relieved. And the general improvement in the phthisical who are suited to altitude treatment is especially marked. It is often pointed out that the food which is usually consumed supplies sufficient iron for the needs of the human body; yet we have abundant clinical experience to show that in most anæmics iron given artificially is of the greatest necessity and service. So that while it is undoubtedly true that a normal man can extract from the air of his locality at sea level all that he needs to keep himself in health, yet when a certain depression of health occurs, he is unable to do so, and often needs to gain the same elements in a somewhat sudden and novel form. It is, therefore, no argument against the therapeutic value of high altitudes as a tonic and alterative in certain conditions of ill health, to urge that the physiological changes whereby these tonic effects are brought about are merely compensatory.

It must, however, be remembered that in using high altitudes for therapeutic purposes, we are taking into our hands a two-edged sword, and if they fail to do good, they may often do much harm. It is, therefore, of vital importance that the therapeutist should study not only the individual and his individual sickness, but also the properties and peculiarities of the climatic remedy he proposes to apply to his disease.

Much interesting and valuable information from a physiological standpoint, the study of which should always precede any therapeutic application, can be obtained from such works as the following: "La Cure d'Altitude," by Paul Regnard; "La Vie sur les Hauts Plateaux," by Drs. Herrera and Lope; "Man in the High Alps" (translation), by Prof. Mosso, of Turin; and many books of travel, such as "Climbing in the Himalayas," by Sir Martin Conway, and "Travels in the Great Andes of the Equator," by Edward Whymper.

Each of the four quarters of the globe has its various high altitude climates. It is only necessary here to refer to those which are at present available for the civilized invalid. On the continent of North America, the Rocky Mountains, extending from British Columbia to the borders of Mexico, have been extensively used; especially on the eastern slopes, for the reason that it is drier and warmer on the lee side, rather than on the western slopes, where the climate is influenced by the damp winds from the Pacific. The climate of these mountain plateaux varies greatly, that of the Canadian portions being comparatively cold and harsh, while that of the more southerly portions, in New Mexico and Arizona, is warm and mild. In Mexico we have lofty plateaux exhibiting the

* S. E. Solly: "Handbook of Medical Climatology," Lea Brothers, p. 42.

special peculiarities of high climates with more genial warmth than those already referred to.

In South America the Andes have been extensively used. Here the high altitudes and medium elevations are warm and pleasant, but the more extreme heights are apt to be made chilly and disagreeable from the condensation of moisture that occurs from the sea winds. In these mountains fog is more common than it is in the mountains of North America at like altitudes.

In Europe the Alps have been extensively used. Here the snow line is much lower, and the cold more pronounced. As most of the resorts are situated in valleys among the snow-clad peaks, and not so far removed from the ocean as in North America, there is more dampness in summer, and more melting snow and precipitation in the spring and autumn. They have, however, the advantage over the plateau resorts of North and South America in having less wind and dust.

The high altitudes of Australia and South Africa are only just beginning to be adapted for use by delicate invalids.

In Asia the Himalayas present fine climates for invalids, but the best of them are on the northern slopes, away from the influence of the monsoons, and are at present not sufficiently civilized to be available.

S. E. Solly.

ALUM, POISONING BY.—Cases of poisoning by this drug are rare. The symptoms appear very soon after the poison has been swallowed. There is severe pain in the œsophagus and stomach, followed by vomiting, often of blood; sanguineous discharges from the bowels, and all the symptoms of a violent gastro-enteritis. The pulse is small and frequent; there is muscular tremor with great weakness; thirst is sometimes excessive, and swallowing is difficult and painful; the body temperature is lowered. Death may occur in syncope. Alkalies and their carbonates and calcined magnesia are the antidotes for alum. After the immediate danger has passed away, the gastro-enteric inflammation remains to be treated on general principles. Chronic alum poisoning is manifested by gastric disturbance and constipation. It is to be treated by first removing the cause, and then combating the effects by means of laxatives and stomachics.

ALUM ROCK SPRINGS.—Santa Clara County, California.

ACCESS.—From San José by carriage seven miles northeast. Hotel.

These springs are located on the western slope of the coast range in a romantic cañon with a most unromantic name—Penitentiary Cañon,—so-called in consequence of the early Jesuits assembling there to do penance. The nearness of the springs to San José and the excellent accommodations offered at the hotel, with the many natural advantages of climate and scenery, make the Alum Rock Springs a favorite resort for tourists, summer visitors, and invalids. The summer temperature is rarely above 90° F., and in the winter it is never too low for comfort. Trout and mountain quail abound, affording good sport for rod and gun. Several springs are in activity at Alum Rock. The principal "soda" or drinking water spring was found by Dr. Anderson to contain the following ingredients:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	7.14
Sodium chloride	10.21
Potassium carbonate	0.76
Magnesium carbonate	8.92
Magnesium sulphate	7.16
Calcium carbonate	19.05
Manganese carbonate	Trace.
Ferrous carbonate	Trace.
Alumina	6.45
Silica	2.52
Total	62.21

Free carbonic acid gas, excess.

This water is of the alkaline-saline-carbonated variety with strongly marked aluminous properties. A chalybeate spring at Alum Rock was analyzed some years ago by Professor Hatch, with the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Ferrous oxide	0.30
Alumina	0.15
Manganese	0.70
Soda	3.40
Potassa	0.20
Chlorine	1.60
Hydrosulphuric acid	3.30
Total	9.65

The salts and elements of this analysis are evidently reduced to an anhydrous state. The same analysis with the water of crystallization would probably yield a much heavier residue.

At Alum Rock there are two thermal sulphur springs which have a temperature of 85° F. They are used for bathing purposes.

The waters at this resort have gained considerable reputation in the treatment of anæmia, chlorosis, chronic malaria, nervous prostration, and debility. They ought, furthermore, to be useful in the hemorrhagic diathesis, in menorrhagia, etc., on account of the iron, alum, and acids which the waters contain. *James K. Crook.*

ALUM ROOT.—(*Heuchera.*) Under this name the rhizome of *Heuchera Americana* L. is used as a simple astringent, by reason of the fourteen per cent. of tannin which it contains. It is a crooked, tuberculate rhizome, five or six inches long and half an inch thick, of a purplish or reddish color, within and without. The plant grows abundantly in the Eastern United States and is represented through the West by other species of the genus, with similar composition and properties. The dose is from 1 to 4 gm. (gr. xv.–lx.). Either water or alcohol will extract its tannin. *H. H. Rusby.*

ALUMINUM.—1. GENERAL MEDICINAL PROPERTIES OF THE COMPOUNDS OF ALUMINUM.—As compared with the majority of the heavy metals, aluminum exerts but an insignificant constitutional action—one useless in medicine, and not certainly recognizable even in poisoning by aluminum compounds. All the evidence there is of constitutional action by this metal is that, in toxic doses of alum, there have been observed along with the symptoms of local irritation, tremors, spasms, fainting fits, and, in one case, death, with disproportionately slight local lesions. Locally, aluminum compounds are astringent—the freely soluble, such as alum, highly so, but yet with less conjoint irritation than is usual with astringent metallic salts. The main therapeutic use of aluminic preparations is for a local astringent effect, for which purpose these compounds combine potency with freedom from bad taste, undue irritation, or power to stain.

2. THE COMPOUNDS OF ALUMINUM USED IN MEDICINE.—These are the hydroxide, sulphate, and potassio-sulphate (potassium alum).

Aluminum hydroxide, $Al_2(OH)_6$.—Aluminum hydroxide, or hydrated alumina, as it is commonly called, is official in the U. S. P. as *Alumini Hydras*, Aluminum Hydrate. It is prepared by precipitation, a boiling hot aqueous solution of alum being poured into a similarly hot solution of sodium carbonate. The precipitate of the hydroxide is then washed with hot distilled water, drained, dried, and pulverized. The product is "a white, light, amorphous powder, odorless and tasteless, and permanent in dry air. Insoluble in water or alcohol, but completely soluble in hydrochloric or sulphuric acid, and also in potassium or sodium hydrate T. S. When heated to redness it loses about 34.6 per cent. of its weight (water of hydration)" (U. S. P.). This preparation, from its insolubility, can exert active properties only through chemical conversion. Locally

for floral decoration. Many species, especially of the narcissus group, are known to be poisonous. They are almost unknown to medical literature, but the agave or century plant is an important source of fermented and distilled liquor in Mexico. The family may be expected to yield important additions to the materia medica.

H. H. Rusby.

AMBER.—SUCCINUM. (Preparation: *Oleum Succini*, U. S. P.).

A fossil resin produced by *Pityoxylon succiniferum* Kr. (*Picea succinifera* Conventz), and other tertiary and long ago extinct *Coniferæ*. The range of these trees must have been a considerable one, as amber has been found in many widely separated places—Siberia, Alaska, Greenland, Maryland, in the United States, and in nearly all quarters of Europe. But the tract now covered by the Baltic Sea must have produced these trees in the greatest abundance; for from its southern borders nearly all the amber of commerce is, and for many centuries has been, obtained. The west coast of Denmark, and nearly the whole north coast of Prussia is included in this amberiferous region. It is continually found cast upon the shores by the waves, especially after heavy storms, either loose or entangled in the "roots" of *fuci* and other marine algæ; it is also fished up from the bottom; and finally, large quantities are dug out of a stratum of glauconitic sand, "blue earth," underlying layers of peat and marl, and extending often far beneath the bed of the sea. It is assorted into numerous grades, according to its purity and size. The finest pieces are cut and polished for articles of ornament, the small and unsightly ones, with the chips and cuttings, are made into varnishes and various compositions, or distilled for the oil.

Amber is found in hard, brittle tears and lumps of more or less rounded but often irregular shape. They are usually small, rarely exceed a few grams in weight, and vary very much in clearness and transparency. They often contain coarse impurities, vegetable remains, and dirt. Occasionally entire insects are beautifully preserved in them. The color of amber is generally yellow or brownish, but varies from almost white to nearly black; it is rarely greenish. The external or natural surface is usually rough or irregular, the interior often beautifully transparent. It is harder than most resins, has no odor or taste, break with a conchoidal fracture, and is capable of receiving a high polish.

It is insoluble in water and cold alcohol, but may be dissolved in boiling alcohol, benzol, etc. It softens at a moderately high temperature, but does not melt until 29° C., when it begins also to decompose. Composition, $C_{10}H_{16}O$, and hydrocarbons.

The use of amber itself in medicine is long past. It is sometimes an ingredient of fumigating powders or pastilles; directions also for making an ethereal tincture are in pharmaceutical works. The oil of amber (*Oleum Succini*, U. S. P.) is an empyreumatic liquid, obtained by dry distillation and purified by distillation from water. The crude oil is a mixture of hydrocarbons and acids; a thick, dark-red, offensive-smelling liquid. The redistilled is pale or white, "a colorless or pale yellow, thin liquid, becoming darker and thicker by age and exposure to air; having an empyreumatic balsamic odor, a warm, acrid taste, and a neutral or faintly acid reaction. Specific gravity about 0.920. It is readily soluble in alcohol," etc. (U. S. P.). It is extensively adulterated. Internally used—*dose*, 2 to 5 dgm. (0.2 to 0.5 gm. = ♏ iij. ad viij. = gtt. 5 to 15)—it is said to be stimulant and antispasmodic. Externally it is rubefacient, and is occasionally used as an ingredient of liniments. The residual pitch, "amber resin," left after the distillation of the oil, is dissolved to make a slowly drying, but very hard and durable varnish. Succinic acid is also one of the products of the disintegration of amber.

ALLIED PLANTS.—For other *Coniferæ* see *Turpentine*.

ALLIED DRUGS.—Oil of tar is chemically and therapeutically analogous to oil of amber. Copal, kauri, and other fossil resins are strictly analogous products.

W. P. Bolles.

AMBERGRIS.—(*Ambre gris*, Codex Med.; *Ambra grisea*, *i.e.*, gray amber.) A peculiar fatty material, found in lumps, generally on the surface of tropical seas; occasionally in the intestines of the sperm-whale, *Physeter macrocephalus* Shaw, where it is supposed to be a pathological formation. The balls are often of concentric structure, and in appearance and position are analogous to concretions found in other animals. Pieces vary in size from small fragments to great masses of 50 kgm. (100 lbs.) or more. It is a waxy, tasteless substance, crumbling, but also softening in the hand, having about the consistency of some gall stones, its color usually grayish or brownish, streaked or spotted with white. Odor slight, peculiar, not nauseous. At the temperature of boiling water it melts, and at a higher one is dissipated, leaving but little residue. Soluble in alcohol, ether, fixed and essential oils, etc.

Ambergris consists to the extent of about eighty-five per cent. of a peculiar non-saponifiable, crystallizable fat, *ambrein*, besides small amounts of extractive, benzoic acid, etc.

Ambergris has been used as an antispasmodic of the musk type, but is probably weaker than that. Its medical use is nowadays not worth serious thought. In perfumery, like musk, it has the property of holding and developing the vegetable odors.

The dose may be accepted as from 0.25 to 1 gm. (= gr. iv. ad xvi.). A tincture would be a suitable form.

W. P. Bolles.

AMBLER SPRINGS.—(Formerly Griffin's Springs.) Pickens County, South Carolina.

POST-OFFICE.—Pickens Court House. Hotel.

These springs are two in number, and are located seven miles from Pickens Court House, at a level of 2,000 feet above the sea. They are used to some extent as a resort, and the water is bottled and sold. The Ambler House is one mile from the springs. It is kept open for the reception of guests during the summer months. The water was analyzed in 1895 by M. B. Hardin, chief chemist of the Clemson Agricultural College, as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	0.80
Calcium carbonate	2.15
Magnesium carbonate	0.65
Potassium sulphate	0.51
Sodium sulphate	0.18
Sodium chloride	0.37
Iron sesquioxide and alumina	0.02
Silica	1.78
Total	6.46

This water is of the light alkaline-calcic class. It is not heavily mineralized, but nevertheless it has been used with much apparent advantage in dyspepsia, and in skin disorders of the eczematous variety.

J. K. Crook.

AMBULANCES, CIVIL.—An ambulance is a vehicle specially designed for the transportation of sick or wounded. It owes its origin and general characteristics to the needs of civilized warfare. The growth of humane practices in the wars of the eighteenth century produced an increasing demand for some method of carrying wounded both effective and merciful, and the French wars following the Revolution of 1789 brought the ambulance service along with all their other military innovations.

An organized system for the transportation of wounded was first introduced by Baron Larrey, the French military surgeon, in the Army of the Rhine in 1792. Only slight improvement upon his system was made during the wars of the first half of the nineteenth century, and it was not until the latter part of the Civil War that the ambulance obtained proper recognition and development

those expedients which have been in use from time immemorial.

The type of ambulance in active operation everywhere is at present the horse ambulance. Bicycle ambulances have been tried, but with little success. It cannot be questioned, however, that before long automobile ambulances will to a great extent supersede all other kinds. The rapid introduction of electric delivery wagons, trucks, and cabs is an indication of what may shortly be expected in ambulances, and there are at present in process of construction several with electric motive power.

All horse ambulances are so nearly alike that one general description will cover all their salient features. The enclosed body of the vehicle is from eight to nine feet long and from three to three and one half-feet wide. As lightness is an important element, it is built of as light material as is compatible with thorough strength. The roof is supported by uprights, a hood projecting over the driver's seat, and only a short distance is boarded in on the sides, the front and rear being open. In cold or stormy weather all but the rear can be closed in by leather or rubber curtains. The patient lies on a movable bed covered with leather, and this runs on a track, and is so held by inverted clamps that it will still remain horizontal when drawn out to its full length. A stretcher lies on this bed. The surgeon sits at the rear on a transverse seat, just over the tail-piece, so arranged that it can be raised perpendicularly and clasped out of the way when the tail-piece is let down for the entrance or exit of the patient. A step behind assists the surgeon to his seat, and there are straps to which he may hold. Under the driver's seat, in front, is room for splints and other appliances, and the longer splints are suspended by straps from the roof. A lantern is clamped inside, and two red lights on the side indicate to other drivers the ambulance's right of way. The fore wheels can be cramped under the fore part of the vehicle, which can thus turn in the shortest possible space. Usually drawn by one horse, it may of course be changed to a double rig whenever circumstances or the conditions of the streets require. The average weight of such a vehicle is from twelve hundred to fourteen hundred pounds. The wheels are made with solid rubber tires, which are as satisfactory and far more durable than the pneumatic tires that were in vogue for a short time. A large foot gong in front of the dashboard, or under it, can be operated by the driver.

The most satisfactory situation for the stable is within the limits of the hospital, but in a separate building. By this adjustment the inevitable noise and odor are minimized, and the ambulance is still within close call. The interior arrangement of the stable need not differ from that of any private one. There should be one more horse than the number of ambulances in service, in case of accident or disease and to meet any emergency. One stall is kept for the horse on call, where he stands with his bridle in place, only the bit requiring to be inserted. The harness is patterned after that used by fire departments, and hangs suspended over the shafts ready to be lowered; then the collar is clasped, one or two straps are buckled, and in a moment or two the trained horse is under way. Calls are sent to the stable from the office by telephone or gong. There must be one more ambulance than the number running, in order that repairs required by accidents and wear and tear may be made without a disabling of the service. So, also, an extra man is needed to take care of the stable, horses, and ambulances, and to act as a relief driver and stable watchman. His extra time may be employed in the doing of other necessary work around the institution.

A conventional assortment of medical and surgical in-

FIG. 92.—Automobile Ambulance.

easily controlled. The advantages of such a vehicle over a horse ambulance are obvious. It does not take up so much stable room, it does away with the noise and odors of a stable, it is always ready when charged, and no harnessing is necessary, and it is less expensive when in actual operation. Its disadvantages are its great price and large cost for repairs, that it needs more skilled and therefore more expensive labor to take care of and run it, that its position at present is rather uncertain owing to the rapid improvement in these vehicles, and that on slippery pavements and in deep snow it is unreliable. Though at present no institution would attempt to run automobile ambulances exclusively, it is highly probable that in a short time they alone will be used.

In New York City the hospitals maintaining a regular ambulance service are the following, the figures indicating the number of ambulances regularly in service in each case: Hudson Street, 2; Gouverneur, 3 or 4; New York, 2; Flower, 2; Presbyterian, 2; J. Hood Wright, 2; St. Vincent's, 2; Bellevue, 4; Roosevelt, 2; Harlem, 2; Fordham, 2. (Each of the hospitals named has one or more ambulances reserved for emergency use.)

Before the general introduction of telephones, calls were usually sent to hospitals by the ringing of a gong, as is now done by the Fire Department. It was also customary at one time for an ambulance to go to every fire call. Since telephones have become so universal they alone are generally used. The ambulance work is under the supervision of the Police Department, and every call is theoretically supposed to be sent by an officer. Practically, however, every reasonable call sent by a civilian is answered. The Fire Department becomes an element in calling ambulances only when there is a large fire with much loss of life. In such case, following the alarm of fire which is rung in almost all hospitals having an ambulance service, a call of three fours is rung to summon all available ambulances in the city; immediate response is made to the call.

Cities differ considerably in the way in which their accident service is done. Sick cases are everywhere handled in much the same way; patients who are too ill or too poor to be taken in carriages are conveyed by ambulances. The accident work in certain cities is done entirely by police patrols. This system has some peculiar advantages; it is not imposed on ignorantly by civilians, or wilfully abused by the police themselves; slight scalp wounds received by "drunk and disorderly" unfortunates do not so often occupy the time of a hospital staff, and cases of pretended illness are more carefully investigated, to the relief of the temper of the hospital authorities, while calls in outlying sections far from a hospital can be answered more readily and promptly. On the other hand, the patients are not handled so carefully or so skilfully, and ignorance does in exceptional cases produce very serious consequences. On the balance of advantage, the individual benefits by the hospital service; the police system is undoubtedly more economical. In some cities public hospitals do all the accident work, the private hospitals only running ambulances for sick cases. Sometimes there are ambulance stables distributed about the city without trained surgical attendants; these carry patients directly to the nearest public hospital; in other cases all calls are sent in to the hospital. The value of prompt transportation without skilful assistance on the one hand offsets the intelligent skill coupled with delay on the other.

The most perfect but most extravagant method is the establishment of an ambulance service in private as well as in public hospitals, and the assignment to each hospital of a limited area, so that all parts of a city can be rapidly covered by intelligent workers. This entails much expense on private institutions, even if laboring under financial difficulties, but is another refinement in the method in which many of our cities look after the welfare of their inhabitants. This is the case in the city of New York, where the Board of Charities divides the city into districts and allots to each district a certain number of police prisons. The districts are so divided as each to contain a hospital maintaining an ambulance service, and the jurisdiction of each hospital within the limits of its own district is complete.

In all cities cases of contagious disease are transferred to reception and contagious hospitals; this is generally done by special vehicles, old city ambulances altered into closed vehicles. There are in many of the cities ambulances operated by private individuals for the purpose of transferring patients in as inconspicuous a way as possible; these are built to represent an ordinary vehicle externally, with a stretcher arrangement within like that of the ordinary ambulances. The varieties are numerous, and that one is best which least attracts attention.

That ambulance services are imposed upon there can be no doubt; unfortunately there seems to be no remedy for the evil. The imposition is sometimes effected through ignorance, sometimes through design. The convenient and efficient practice of calling ambulances by telephone increases the opportunity for mischief. To the hysterical layman every attack of syncope means apoplexy, and every abrasion of the scalp a fractured skull. When these or kindred things come to his attention, he immediately sends in a "hurry call" by the nearest telephone, often without the knowledge or desire of the patient; when it is answered with all possible speed, the surgeon finds that the patient has gone home or refuses treatment. By ambulances, also, ready means is afforded to the policeman to dispose of his obstreperous and slightly battered alcoholic charges, and when no evidence of injury is apparent the surgeon is solemnly told that the patient was comatose when the call was sent. A hospital that does not leave anything to the discretion of the surgeon, but insists on all cases being brought in unless refused, of course suffers most in this way. No remedy that will throw out all improper calls and answer all the worthy ones can be devised, and, as in the fire service, much time and money are sacrificed in order that no single case requiring attention shall be neglected.

The position of ambulance surgeon is usually filled by internes or by physicians specially appointed for the purpose, or by students nearing the completion of their medical school course. There can be no doubt of the inadvisability of allowing medical students to occupy so important a position. Most cases require simple treatment, but exceptional circumstances arise, and one untrained to meet them is little better than a layman. Such training as a service requires can be readily and thoroughly acquired in an emergency ward, under competent supervision, and as either of the first two methods brings every benefit to the patient, the choice must fall upon the one which better meets the requirements of the service without affecting the administration of the hospital as a whole. A very active ambulance service is too much of a drain upon the strength of a man busy with additional work; on the other hand, such a service is but a slight inducement to a capable man, unless, as is seldom the case, it offers chance of future advancement. The question is open, and is decided in each case by existing conditions.

The following statistics may be of interest as showing the development of the ambulance system in some of the leading hospitals of New York City:

Hospital.	Year of establishment.	Number of calls in first year.	Number of calls in 1899.
Harlem	1884	....	3,608
Gouverneur	1885	....	4,835
New York	1877	480	2,028
Presbyterian	1880	276	2,152
J. Hood Wright	1885	....	1,868
St. Vincent	1879	823	2,551
Bellevue	1869	1,466	6,835
Roosevelt	1877	273	4,041
Fordham	1892	272	1,300

John Howland.

AMENORRHŒA.—Disregarding refinements of nomenclature, we may define amenorrhœa as a suspension or cessation of the menstrual function in a woman who is not pregnant and who has not reached the "change of life," or the period at which menstruation naturally ceases. The term should not be employed to include cases in which menstrual blood really exudes from the uterine mucous membrane (or from that of the oviducts, if we accept the doctrine that the Fallopian tubes take part in the function), but is prevented from making its appearance externally by some malformation, such as an imperforate hymen. It should be borne in mind that amenorrhœa is not in itself a disease, but simply a result of some morbid condition affecting either the system at large or some part of the genital apparatus.

CAUSES.—There is scarcely any derangement of the general health, especially if of a serious nature and chronic in its course, that is not prone to prove at least the predisposing cause of amenorrhœa. Usually, however, these deviations from health affect either the function of hæmatosis, the general nutrition of the body, or the normal action of the nervous system, and any two, or all three, of these disturbances may be combined. Moreover, it may be said that defective hæmatosis is itself a nutritive disorder, and that all irregularities of nutrition may take their origin in impaired nervous action. All this is true, but the practical utility of these distinctions remains, nevertheless. Of the particular diseases that give rise to amenorrhœa, the most noticeable are pulmonary consumption and chlorosis. In both instances, the suspension of menstruation seems to be a conservative effort on the part of nature to spare the system every unnecessary tax, and this consideration alone ought to be enough to teach us that it is not the re-establishment of the menstrual flow that we should aim at, but rather the restoration of the general health.

It has been doubted by good observers whether it is possible for a woman in perfect health to suffer from amenorrhœa, and there is much to sustain this position; but it is certain, nevertheless, that in many cases the impairment of the general health goes on for a long period without producing amenorrhœa, until, finally, some additional factor comes into play, and may truly be looked upon as the exciting cause of the disorder. Among these exciting causes we may reckon almost all pelvic diseases, the functional perturbation consequent on exposure to cold during a menstrual period, emotional shocks, and traumatic injuries. It will be seen that these factors must vary widely in their mode of action.

VARIETIES.—Doubt has been cast upon the doctrine that the menstrual function is dominated by the ovaries, but it cannot be said that the doctrine has been overthrown, and we have, therefore, to distinguish, for purposes both of diagnosis and of prognosis, between amenorrhœa which is and that which is not due to failure on the part of the ovaries. In other words, concerning ourselves only with the mechanism, and leaving ultimate causes out of account for the time being, we have to distinguish between uterine and ovarian amenorrhœa. Practically, the only guide we have to a failure of that ovarian action which should serve to stimulate the menstrual flow, is the absence of the menstrual "molimen"—the *ensemble* of symptoms usually attendant upon the flow, including a sense of weight and pain in the pelvis, and in some cases pain, tenderness, and swelling of the breasts, with or without the various reflex disturbances that sometimes attend the menstrual effort.

The uterine variety is to be recognized by the state of the uterus, which will commonly be found to be one of atrophy (including the so-called "superinvolution") or of impeded circulation due to the contraction of old inflammatory exudates.

DIAGNOSIS.—Amenorrhœa, as it is here defined, requires to be disagnosticated only from retention of the menses and from the physiological suspension due to pregnancy. The diagnosis will necessarily rest upon a physical examination, and for the details the reader is referred to the articles on *Pregnancy* and on *Menses, Retension of*.

PROGNOSIS.—The question of our ability to restore the menstrual function is to be answered wholly in the light of the causes on which its suspension is found to depend. Grave constitutional diseases, such as phthisis pulmonalis, render the treatment in that direction not very promising, while the cure of any less serious fundamental disorder may, on the other hand, be reasonably expected to be followed by the re-establishment of menstruation. As regards the local conditions, atrophy of the uterus and functional inactivity of the ovaries must give rise to an unfavorable prognosis, although temporary benefit may be produced by treatment in some instances. The prospect is better in the case of old inflammatory disease within the pelvis, for such affections are often amenable to treatment. In general, the causes will be found to be remediable, and, therefore, the prognosis favorable.

TREATMENT.—In the first place, the practitioner should avoid taking the patient's view of the matter—that she would "feel better if her courses would only come on." Women very commonly express themselves in some such phrase, and they apply to a physician under the idea that his art will bring on the menstrual flow promptly, and thus restore them to health. From what has been said of the causes of amenorrhœa, the reader will have inferred that any such expectation on the patient's part is likely to bring disappointment to her, and, if he allows it to go on, discredit upon himself, for, in all probability, he will not be able to meet the demand made upon him. It is better to give the patient to understand, at the outset, that her condition might be expressed more truly by a change in the phrase alluded to, namely, that her courses will come on when her health has been re-established.

Another caution needs to be given. Women who know or suspect themselves to be pregnant, frequently consult a physician in the hope that, in the attempt to bring on menstruation, he will really succeed in causing abortion. Whoever, under such circumstances, prescribes any measure, no matter how innocent, with the understood purpose of inducing the menstrual flow, is liable to have unpleasant charges brought against him in case abortion actually does take place, even as the result of some interference with which he had no connection. When called upon to undertake the treatment of a case of suppressed menstruation, it is prudent, therefore, for the practitioner to satisfy himself that pregnancy does not exist, and, in case of doubt, to decline the management of the case unless he can protect himself in some way, as by insisting that some trustworthy person be made acquainted with the facts at the start.

Having undertaken the management of a case in which treatment is sought for on account of amenorrhœa, the physician should make a systematic inquiry into the patient's state of health, and whatever deviation from the normal standard is found should be made the subject of treatment. For the details of such treatment, the reader is referred to the articles devoted to the various diseases that may be found. But, while insisting upon the general futility of measures addressed to the organs concerned in the menstrual function, without first attending to the general health, I must admit, nevertheless, that stimulation of those organs may be resorted to with some chance of success when no other indication can be made out; and, moreover, that, in cases in which there are other indications at first, there often comes a time when the result aimed at may be hastened by measures that operate directly upon the pelvic organs.

There are but few therapeutic procedures that have a direct and unequivocal influence upon the function of menstruation, and, in so far as they tend to relieve amenorrhœa, those few act as local stimulants. The so-called emmenagogues are not much to be depended upon, although we may admit that aloetics and chalybeates tend to produce a pelvic congestion favorable to heightened functional activity of the sexual organs. Their use, however, in the absence of other indications than the mere failure of the menstrual flow, is not to be recommended, although, if employed in conformity with such indications, they undoubtedly exert a certain influence.

As a matter of fact, they are often indicated, and it is seldom improper to resort to them.

The preparations of manganese have come into use of late years, having been recommended by Dr. Ringer and Dr. Murrell, of London (*Lancet*, January 6, 1883). One-grain pills of potassium permanganate may be administered, beginning with one pill three times a day, and increasing to two four times a day. The use of the drug should be begun three or four days before the time at which a menstruation should take place, and be continued, if the flow does not come on, until the time for the next period. It should be kept up also during the flow. Both sodium manganate and manganese binoxide are said to be equally effective, and it is stated that manganese acts as well with the plethoric as with the anæmic. Manganese has been tried extensively in this country, but the results have not, on the whole, justified the expectations with which its employment was begun.

There are several other drugs that have more or less repute in the treatment of amenorrhœa. Among them is apiol, which is said to act best in cases in which whatever flow there may be is ill-smelling. From eight to ten minims should be given daily during the week preceding the day for menstruation to begin, and fifteen minims on the morning of that day. Cimicifuga has been thought serviceable in cases of delayed or arrested menstruation. Senecio vulgaris has recently been recommended in cases unaccompanied by pelvic lesions. In the ovarian variety of amenorrhœa, " ovarine, " a preparation made from the expressed juice of the fresh ovaries of healthy young animals, has been used with success. Aloes undoubtedly aids the action of the other so called emmenagogues, and should be employed if there is constipation.

Electricity probably acts more directly as a provocative of menstruation than any other agent. Good effects may be produced by either the galvanic or the induced current, but the choice should not be a matter of mere caprice or convenience. Galvanism is more to be relied on for increasing the blood supply of the uterus, while faradization is useful to intensify and precipitate the hemorrhagic effort. To accomplish the latter purpose, the application ought to be made at a time when the degenerative changes in the endometrium have advanced to such a degree that heightened blood pressure, aided by muscular action, may operate at the greatest advantage in producing rupture of the capillaries. This condition can be judged to be present only when there are some symptoms of ovulation, or when the amenorrhœa is of such recent date that the time for a menstrual flow to fall due is accurately known. In the use of galvanism, it will generally be prudent to place both electrodes on the external surface, unless the current is quite weak and the sitting a short one; aiming, however, to pass the current directly through the uterus. When the faradic current is employed, on the other hand, one electrode should be applied within the vagina, or even within the canal of the cervix.

Milder measures than the use of electricity will often succeed, especially where there is not complete absence of the flow, but scantiness and lack of color of the discharge. Among these measures, refrigeration of that portion of the spinal region corresponding to the motor centre of the uterus is of great value. The skin over the junction of the dorsal with the lumbar vertebræ may be sprayed with ether, but not frozen, three or four times a day, for five or ten minutes at a time, or ice-water compresses may be applied. These means are supposed to exert their effect by depressing the activity of the vasomotor nerves. They are to be used only at the time when a menstrual flow is due. In the interim, an auxiliary measure of some value consists in the use of a very brief cold hip bath every night. *Frank P. Foster.*

AMERICAN CARLSBAD SPRINGS.—Washington County, Illinois.

POST-OFFICE.—Nashville. Hotel Carlsbad.

These springs are located in Nashville, a well built little city of three thousand inhabitants, fifty miles from St. Louis, Mo. Both the Louisville and Nashville and the Chester and Centralia railroads pass this point. The Carlsbad is a modern hotel with all the approved comforts and conveniences. It was erected in 1893, and is located within the city limits, in a natural park of twenty-three acres, with a lake for boating and fishing. It is well furnished throughout, heated with steam and lighted by electricity. The bath house has separate arrangements for ladies and gentlemen, with porcelain bathtubs and conveniences for steam, vapor, and shower baths. The environs of Nashville are very attractive, abounding in delightful drives, picturesque walks, etc.

The following analysis of the water was made by Dr. Ludeking, of St. Louis:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	10.00
Calcium sulphate	65.80
Sodium sulphate	53.00
Magnesium sulphate	103.70
Sodium carbonate	27.40
Total	259.90

The water is evidently of the sulphated saline variety. An analysis by W. F. Hillebrand, acting chemist of the Interior Department at Washington, shows the sulphate of soda to be greatly in excess of the magnesium sulphate. According to Hillebrand's analysis, these waters are very similar to those of the Sprudel Mühlbrunn and Schlossbrunn Springs at Carlsbad. They possess potent cathartic and diuretic properties and are undoubtedly valuable for medicinal purposes. They have been found beneficial in most of the conditions for which Americans cross the ocean to visit Carlsbad, viz., chronic constipation, torpid states of the liver, rheumatism, renal and urinary disorders, and eczematous skin affections. *J. K. Crook.*

AMERICANUS MINERAL WELL.—(Formerly Michigan Congress Well.) Ingraham County, Michigan.

POST-OFFICE.—Lansing.

ACCESS.—By numerous railroads to the city of Lansing.

Under the name of Michigan Congress Water the product of this well has been in use for many years past. The following analysis was made, we believe, by Dr. Jennings, of Detroit:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium phosphate	25.04
Sodium chloride	183.84
Sodium bicarbonate	93.40
Magnesium bicarbonate	67.13
Iron bicarbonate	3.06
Lithium carbonate	0.08
Calcium carbonate	85.90
Potassium sulphate	12.45
Silica	33.00
Alumina	Traces.
Sodium iodide	Traces.
Calcium phosphate	Traces.
Total	503.90

Carbonic acid, 190.29 (grains ?).

This water bears considerable resemblance to that of some of the Saratoga Springs. It retains a uniform temperature of 53° F. the year round. The water is highly recommended in cases of acid dyspepsia, the headaches following alcoholic excesses, etc. It has also been used with good results in lumbago, gout, and various urinary and renal disorders. The water is used commercially.

J. K. Crook.

AMMONIA AND AMMONIUM SALTS.—1. GENERAL MEDICINAL PROPERTIES OF AMMONIUM COMPOUNDS.—Ammonium compounds, as a class, are irritant, locally, to a degree greater than that shown by the corresponding compounds of sodium, but less than in the case of compounds of potassium. They tend to be of high diffusion power, and are therefore, when swallowed, quickly absorbed, and hence are free from the purgative tendency of the low diffusion salts of potassium, sodium, and mag-

to one teaspoonful, diluted with three or four volumes of water. Secondly, ammonia may be given for the constitutional effects of reviving the heart in faintness, of supporting it in chronic conditions threatening heart failure, of stimulating flagging respiration, as in dyspnœa from lung disease, or respiratory failure in poisoning by paralyzing agents, of allaying mild spasmodic seizures, and of opposing generally the action of narcotics and paralyzers. For all internal medication the stronger water is entirely too strong, and the weaker water or the spirits are to be preferred. Of the water or of the simple spirit from ten to thirty drops may be administered at a dose, largely diluted. If swallowing be impossible, as in case of unconsciousness from a faint, the effects of ammonia may be obtained by inhalation, but great caution is necessary lest dangerous, or even fatal, irritation of the air passages be set up by too strong inhalation during complete or semi-unconsciousness. None of the pharmacopœial ammoniacal solutions should be applied close to the nostrils.

Acid Ammonium Carbonate, NH_4HCO_3.—Upon subliming a mixture of chalk and ammonium chloride or sulphate, double decomposition ensues, and a sublimate is obtained which consists of acid ammonium carbonate and ammonium carbamate, represented by the symbol, $NH_4HCO_3.NH_4NH_2CO_2$. This composite salt is official under the title *Ammonii Carbonas*, Ammonium Carbonate. It occurs as "white, hard, translucent, striated masses, having a strongly ammoniacal odor without empyreuma, and a sharp, saline taste. On exposure to the air, the salt loses both ammonia and carbonic acid, becoming opaque, and is finally converted into friable, porous lumps, or a white powder. Slowly but completely soluble in about five parts of water at 15° C. (59° F.); decomposed by hot water with the elimination of carbonic acid and ammonia. By prolonged boiling with water the salt is completely dissipated. Alcohol dissolves the carbamate [$NH_4NH_2CO_2$], and leaves the acid carbonate (ammonium bicarbonate). When heated, the salt is completely volatilized, without charring. The aqueous solution possesses a strongly alkaline reaction, and effervesces with acids" (U. S. P.). This salt must be kept in well-stoppered bottles in a cool place.

Ammonium carbonate behaves, physiologically, like ammonia itself, but is a little less rapid and evanescent in operation. In concentrated solution it is locally irritant, and taken internally, dangerously poisonous. The salt is used for the constitutional stimulant and sustaining effects of ammonia, and is often for such purpose preferred to solutions of ammonia because of the slightly longer duration of the action. It is given internally in frequently repeated doses of from 0.30 to 0.60 gm. (gr. v.–x.) in aqueous solution, with the acrimony disguised by gum arabic or sugar, or some agreeably flavored aromatic addition. Large single doses should be avoided, since they easily over-irritate the stomach and may excite vomiting. Ammonium carbonate is also much used to get an ammoniacal effect by inhalation. For this purpose it is coarsely bruised, treated with half its bulk of strong water of ammonia, and flavored with a little oil of lavender or bergamot, such mixture constituting what is known as *smelling salts*.

Ammonium Acetate, $NH_4C_2H_3O_2$.—This salt is used only in the aqueous solution in which it results from the procedure of neutralizing with ammonium carbonate the diluted acetic acid of the Pharmacopœia. Such solution, commonly called *spirit of mindererus*, is official as *Liquor Ammonii Acetatis*, Solution of Ammonium Acetate. It is "a clear, colorless liquid, free from empyreuma, of a mildly saline, acidulous taste, and an acid reaction" (U. S. P.). The solution contains about seven per cent. of the salt. It should be made freshly for use, since like other solutions of alkaline salts of the common organic acids it tends to spontaneous decomposition on keeping. Ammonium acetate is a bland, mawkish salt, which upon absorption may prove feebly diaphoretic or diuretic, according to circumstances, and may to a slight degree exert the characteristic effects of the ammonium compounds generally. It is used to allay headache, especially the headache of pyrexia, to quiet an uneasy stomach, or to promote gentle diaphoresis or diuresis in fever; but it is at best a feeble medicine. One or two tablespoonfuls may be given at a dose, clear or diluted, sweetened and aromatized. If diluted, carbonic acid water makes an excellent addition.

Ammonium Nitrate, NH_4NO_3.—The salt is official in the U. S. P. as *Ammonii Nitras*, Ammonium Nitrate. It is not used in medicine, but inasmuch as one of its pharmaceutical uses may need to be availed of by the physician himself—namely, the making from it of nitrogen monoxide gas—the pharmacopœial description and also tests for purity are here appended: "Colorless crystals, generally in the form of long, thin, rhombic prisms, or in fused masses, without odor, having a sharp, bitter taste, and somewhat deliquescent. Soluble, at 15° C. (59° F.), in 0.5 part of water, and in 20 parts of alcohol; very soluble in boiling water, and in 3 parts of boiling alcohol. When gradually heated, it melts at 165° to 166° C. (329° to 330.8° F.); at a temperature between 230° and 250° C. (446°–482° F.) it is decomposed into nitrogen monoxide gas and water, leaving no residue. The aqueous solution of the salt is neutral to litmus paper, and, when gently heated with potassium or sodium hydrate T. S., it evolves the odor of ammonia. On heating the salt with sulphuric acid, it emits nitrous vapors. A ten-per-cent. aqueous solution of the salt, when acidulated with nitric acid, should not be affected by silver nitrate T. S. (absence of *chloride*), nor by barium chloride T. S. (absence of *sulphate*)" (U. S. P.).

Edward Curtis.

AMMONIA, TOXICOLOGY OF.—Ammonia is met with in commerce in a number of forms.

First, as anhydrous ammonia condensed in large steel cylinders for use in ice machines. In these the ammonia is under a pressure of several hundred pounds and is in a liquid condition. When the pressure is removed, the liquid assumes a gaseous form and issues from the opening as a colorless, irrespirable gas intensely corrosive to organic tissues.

A number of fatal accidents have happened from the action of this gas, either through the bursting of the cylinder when it has been highly heated, or through imperfect connection with the refrigerating machine.

Second, as a clear, colorless solution containing twenty-eight per cent., by weight, of the gas dissolved in water, the *Aqua Ammoniæ Fortior* of the pharmacist. This solution, exposed to the air, loses strength rapidly through volatilization of the gas, and rapidly deteriorates, especially in a warm atmosphere. If kept in a bottle with an ordinary cork, it gradually corrodes and softens the tissues of the cork, turning it dark and so destroying it that, after a time, it falls readily to pieces. The gas arising from the solution is pungent and irrespirable.

Third, a solution containing ten per cent., by weight, of the gas dissolved in water—the *Aqua Ammoniæ* of the pharmacist. This solution is made from the *Aqua Ammoniæ Fortior* by dilution with water. This is like the preceding solution, though less corrosive.

Fourth, a solution of varying strength containing a number of impurities sold under the name of Household Ammonia.

Poisoning from gaseous ammonia is always the result of accident, and such cases occur only in plants where the gas is stored or where it is used in quantity for refrigerating purposes. Poisoning by inhalation of the gas arising from its water solution has also been known as the result of accident. Such a case occurred in the writer's laboratory, where a carboy containing about ninety-five pounds of the saturated solution cracked so that the entire contents were soon spread over the laboratory floor. The young man in the laboratory at the time was just able to reach the door in a condition of suffocation. He complained of feeling drowsy and weak, and of soreness in the bronchial tubes as in a case of bron-

The plant is filled with an abundance of milky juice, contained in both stem and roots, which exudes either spontaneously or from punctures made by a beetle which feeds upon it. The sap, as it escapes, hardens and dries upon the stem, and flows or drops to the ground. It is collected in July and August, partly from the stems, partly from the ground, by Persian peasants, and exported to India, and from there to Europe.

Ammoniac consists of these hardened drops, or "tears," as they are technically called. In the best qualities they are separate, or only loosely stuck together in porous masses; in inferior grades they are embedded in a dark-brown resinous matrix. Fine specimens consist of rounded pieces from 1 mm. to 1 or 2 cm. (one twenty-fifth to three-quarters of an inch) in diameter. They are brownish cream-colored externally, darkening to cinnamon brown with age, creamy white, or pure white within. They break with a conchoidal fracture, disclosing a waxy, but shining surface. The odor is peculiar, rather disagreeable, but faint, excepting in masses or upon warming; the taste is bitter and rather acrid. Inferior specimens are those having a large proportion of the darker, homogeneous resins and extraneous substances, such as dirt, sticks, chaff, etc. It is a difficult drug to powder, unless very cold or very dry. When heated it softens, but does not melt. Alcohol dissolves about three-fourths of it. Water disintegrates it, and forms with it a milky emulsion.

Ammoniac consists of about seventy per cent. of resin, fifteen to eighteen per cent. of soluble gum, and the rest of insoluble gum, water, and a trace of essential oil. The latter, according to Flückiger, does not contain sulphur, and, therefore, is not similar to the oil of asafœtida.

Ammoniac is stimulant, expectorant, and antispasmodic, but is scarcely used now internally. The dose is stated to be 0.5 to 2 gm. (gr. viij.–xxx.) three or more times a day. An emulsion would be an eligible form, although a tincture would probably contain all that is active in it. The only official preparation is Ammoniac Plaster (*Emplastrum Ammoniaci*, U. S. P.), made by softening the ammoniac in diluted acetic acid, and evaporating to a suitable extent. It is a stimulating and rubefacient, sometimes blistering application, useful as a mild counter-irritant.

One other species of *Dorema*, according to the "Pharmacographia," yields ammoniac. Bentham and Hooker include only two species in the genus. The ammoniac of Dioscorides and Pliny, and other ancient writers, was obtained in Africa, and is a different article, namely, a gum resin obtained from *Ferula Tingitana* Linn. It is rarely found in European markets. *W. P. Bolles.*

AMMONOL.—A proprietary remedy stated to be ammonium phenylacetamide and recommended as antipyretic, analgesic, and antiseptic. Dose, gr. v.–xx.

Ammonol Salicylate.—A salicylic acid compound of ammonol, claimed to be especially useful in the headache of nervous and anæmic patients, and given in eight-grain doses. Both ammonol and its salicylate are white powders which lose ammonia on exposure to air.

W. A. Bastedo.

AMNESIA. See *Aphasia.*

AMNION.—The amnion is one of the fœtal appendages, being a thin membrane which is derived from the extra-embryonic portion of the somatopleure, and forms the innermost of the envelopes surrounding the fœtus. It occurs only in mammalia, birds, and reptiles (the amniota), and is absent in the amphibia and fishes (the anamniota). Among the invertebrates an amnion is developed by the embryos of many insects. The vertebrate animals which exhibit an amnion are also characterized by the possession of the allantois, another fœtal appendage. These two structures, the amnion and allantois, though associated together in existing species, are distinct in their histological origin and development.

The amnion is a thin, delicate membrane or sac which is situated next to the embryo, separated from it by a space or accumulation of fluid; outside the amnion are the chorion and allantois, and outside these (in mammals) the uterine walls. At an early period the amnion is a separate sac, distinct from the chorion, but later it comes into contact with and is loosely attached to the chorion. In the fully developed human afterbirth the amnion is a well-marked, thin, pellucid membrane lining the inner surface of the placenta and fœtal membranes, from which it can be easily stripped off. At the insertion of the umbilical cord into the placenta the amnion merges into the integument of the cord, which differs somewhat in character from the remainder of the amnion. At the junction of the cord with the abdominal wall, the superficial layers of the cord become continuous with the skin of the fœtus. Hence the amnion is a structure continuous (through the integument of the cord) with the skin, and in the main it is genetically as well as structurally homologous to the skin. The amnion possesses two layers: the superficial layer (that directed toward the fœtus) is of epiblastic origin and epithelial nature, and is the precise homologue of the epidermis; the deeper layer is a connective-tissue stratum of mesoblastic (somatopleural) origin, and corresponds in the main to the cutis vera. Within the amnion is a cavity, the amniotic cavity, which is filled with a fluid (the amniotic fluid), in which the fœtus is immersed.

A distinction is sometimes made between the true amnion and the false amnion. The true amnion is the amnion proper, the innermost of the fœtal envelopes. The false amnion, or "membrana serosa," consists of that portion of the extra-embryonic somatopleure which enters into the formation of the chorion; the chorion is formed by the fusion of the false amnion and the allantois.

Development of the Amnion.—The ontogenetic development of the amnion in all reptiles and birds (which together are often called the sauropsida) appears to take place by substantially the same process, which is well exemplified in the classical case of the chick. In the mammalia, however, there are several important differences and variations in the mode of amnion formation, though in many of the mammals the process is similar to that in the sauropsida.

The development of the amnion is in some cases associated and complicated with that of another membrane, the proamnion: this is a fold of epiblast and hypoblast which covers the anterior portion of the embryo, and is usually a transient structure. It differs from the amnion in consisting of ectoderm and entoderm without intervening mesoderm or cœlom, while the amnion is formed from the somatopleure. It is considered in a separate article.

Preliminary to considering the development of the amnion, it will be convenient to recall some of the features of the early embryo. At a certain early period the embryo exhibits three layers, the epiblast (ectoderm), mesoblast (mesoderm), and hypoblast (entoderm), from without inward. Outside the epiblast there is also another layer, known chiefly under the German term *Deckschicht*, or Rauber's layer, probably to be regarded as a portion of the epiblast. In many cases this outer layer early disappears and may be disregarded; but in numerous species the *Deckschicht* plays a very important part in the formation of the amnion. The mesoblast early splits into two layers, the cleft beginning near the longitudinal axis of the embryo and extending laterally outward. The outer layer thus formed is called the somatic layer of the mesoblast, and it with the epiblast are together termed the somatopleure. The inner layer is the splanchnic layer of the mesoblast, and with the hypoblast forms the splanchnopleure. The cleft or space between the two layers of the mesoblast is called the cœlom or pleuroperitoneal cavity. The layer of cells lining the cœlom has been termed (Minot) the mesothelium, while the rest of the mesoblastic tissue has been called the mesenchyma.

Amnion Formation in Reptiles and Birds.—The de-

velopment of the amnion appears to take place in substantially the same manner in all birds and reptiles, practically as exemplified in the chick.

In the chick, as typical of the sauropsida, the formation of the amnion begins with the growth of a crescentic

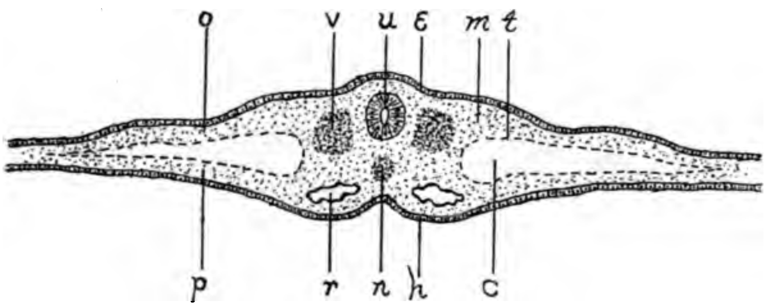

FIG. 94.—Early Development of Embryo, Prior to Beginning of Amnion Formation.

fold of the somatopleure upward in front and at the sides of the cephalic extremity of the embryo, which becomes sharply flexed on the body of the embryo. This fold grows up over the head as a sort of hood, and gradually extends backward. Later a similar but smaller somatopleural fold grows up over and envelops the posterior end of the embryo.

The fœtal body at the same time sinks downward and lateral folds grow up at its sides. As the cephalic somatopleural fold grows backward, the posterior fold forward, and the lateral folds upward and inward, the margins of these folds finally come to meet in a line over the dorsum of the embryo. The edges of the folds then grow together: first the epiblastic cells unite, then by the extension of the mesoblast and the cœlom complete union is effected, and two complete and separate membranes are formed over the dorsum of the embryo. The inner of these is the amnion; the outer (the "false amnion" or membrana serosa) enters into the formation of the chorion, and comes into vascular connection with the embryo by means of the allantois. This process is gone through during about the second, third, and fourth days of incubation, and is illustrated by the accompanying figures (Figs. 94 to 98). Later, the amniotic cavity extends underneath the embryo, so that the fœtal body comes to be completely enveloped in the amniotic membrane.

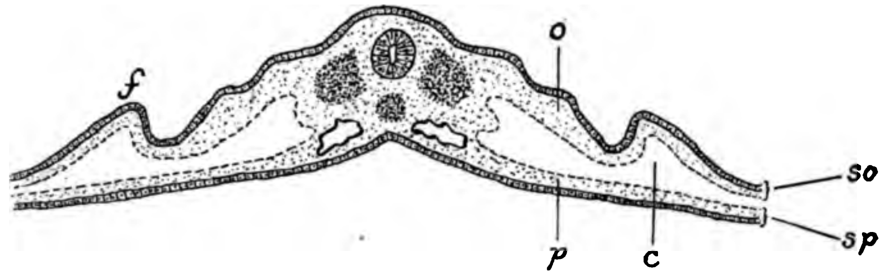

FIG. 95.—Beginning of Formation of Amnion by Upward Growth of Folds of the Somatopleure.

In the ova of *insects* an epiblastic membrane, corresponding closely to and probably analogous with the amnion of the vertebrate amniota, develops so as to envelop more or less of the embryo and enclose a small cavity. This membrane is formed by the growing up and coalescence of folds in a manner strikingly similar to that exhibited by the chick.

Amnion Formation in Mammalia.—There is considerable variety and diversity in the details and the general features of the process of amnion formation in the different varieties of mammalia. In many mammals the process is, in the main, similar to that exhibited by the sauropsida, though with differences in the details; but in other species there is a wide departure from the type presented in the chick. The process is not even uniform within the same orders of mammals, but great differences may occur between allied genera. While the embryology of many species has been worked out, it will still require extensive researches among different varieties of mammals to determine all the forms of amnion development. A few of these forms are briefly described below.

In the *rabbit* the amnion is derived from a somatopleural fold like that in the chick, which begins, however, only at the caudal extremity and gradually grows forward over the embryo (Fig. 99). The anterior end of the embryo becomes covered by a large proamnion, but by the forward growth of the posterior amniotic fold the proamnion is ultimately obliterated and replaced by the true amnion.

In the *opossum* a similar caudal amnion fold grows up at first, but this disappears and is replaced by proamnion, which ultimately covers the entire embryo.

In the *hedgehog*, according to A. A. W. Hubrecht ("Die Phylogenese des Amnions und die Bedeutung des Trophoblasts," Amsterdam, 1895), the *Deckschicht* (or "trophoblast") plays an important part in the formation of the amnion. A space (*a*, Fig. 100) early appears between the formative epiblast (*e*), or epiblast that is to take part in the formation of the embryo, and the overlying portion of the *Deckschicht* (*b*); this space is to develop into the amniotic cavity. From the inner surface of this overlying portion of the *Deckschicht* (*b*) a layer then

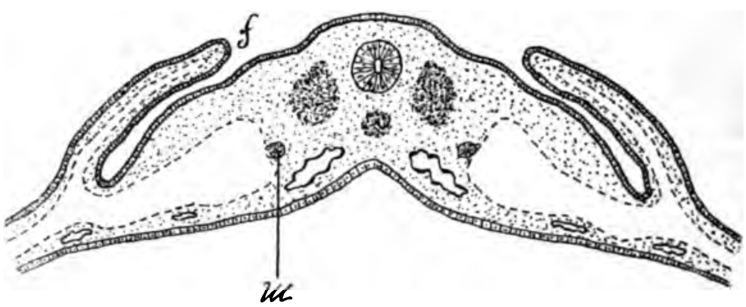

FIG. 96.—Amnion Formation Further Advanced.

splits off, beginning at the margin of the formative epiblast, and the cœlom and somatic layer of the mesoblast at the same time grow into the cleft thus formed. By the complete splitting off of this inner layer (*u*, Fig. 101) from the *Deckschicht* the amnion is formed, the *Deckschicht* remaining to take part in the formation of the chorion.

Hubrecht also describes modifications of this process of amnion formation in other animals.

In many of the *rodents* (but not all) a peculiar process occurs, known as the "inversion of the germ layers," in which the *Deckschicht* plays an important part. A proliferation of cells takes place at one point of the *Deckschicht*, forming a cellular mass known as the *Träger*,

and which ultimately takes part in the formation of the placenta. The epiblastic cells beneath the *Träger* also accumulate in a mass, so that the two masses of cells, those of the *Träger* and those of the epiblast, together form a sort of plug, which projects into and fills the cavity of the blastoderm. The hypoblast lining the *Deckschicht* and epiblast is thus invaginated into itself: that portion of it covering the mass of epiblastic cells appears to be external while the epiblastic cells seem to be internal, the usual relations of these two layers thus appearing to be reversed. The relations are precisely similar to those of the heart and pericardium, the myocardium corresponding to the *Träger* and epiblast, the pericardium to the hypoblast; while the myocardium appears to be inside the pericardium, it is really outside the pericardial cavity. In some species—Mus musculus (house mouse), Mus decumanus (rat), Mus sylvaticus—the *Träger* and the epiblastic mass coalesce and merge into one another, forming a cylindrical mass within which a cavity appears (Fig. 102). In the epiblastic portion of this cylindrical mass the embryo develops, and by the growing together of folds or constrictions above the embryo a portion of the cylinder is cut off to form the amnion and amniotic cavity.

Similar modes of amnion formation, but differing in certain particulars, are exhibited by other rodents, as in arvicola (field mouse) and the guinea-pig. For detailed illustrations and descriptions of the development of the amnion in various rodents, reference may be made to E. Selenka's "Studien über Entwickelungsgeschichte der Thiere," Heft iii., Wiesbaden, 1884.

In the *ruminants* the amnion develops very early. In these a cord of tissue (the "amniotic cord" or "funiculus amnii") persists for some time at the point of final closure of the amnion and chorion (*t*, Fig. 97) and forms a band connecting the two membranes.

In *man* little is known as to the early mode of development of the amnion, owing to the difficulty of obtaining specimens for examination. The earliest stage observed has been described by His, and as interpreted by him is diagrammatically represented in Fig. 103. Beneath the embryo was the yolk sac, and posteriorly an allantoic stalk (the future umbilical cord) connected the embryo with the chorion. The amnion was given off from beneath the cephalic extremity of the embryo, at the margin of the yolk sac, and passed backward over the embryo to join the allantoic stalk. The precise mode by which this arrangement of the amnion is attained is unknown. His's theory, illustrated by Fig. 104, is that the embryo sinks from the surface of the blastodermic vesicle, and a somatopleural amnion fold grows from the anterior extremity backward over the embryo. Spee has conjectured that some process similar to the inversion of the germ layers in rodents takes place. The amnion springs from the sides of the

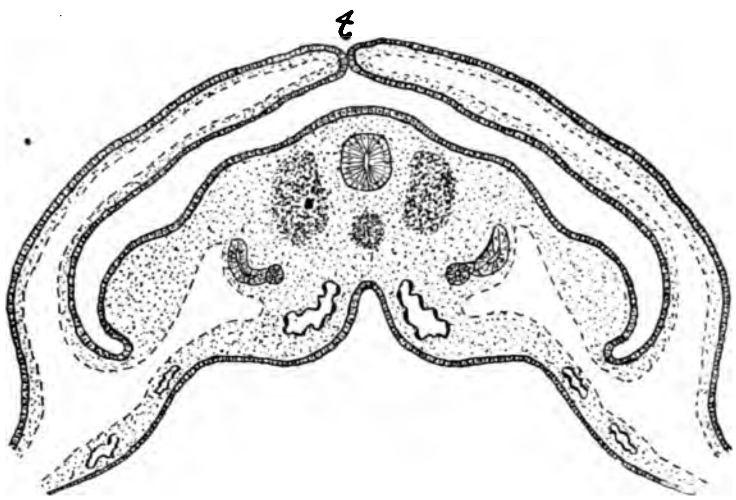

FIG. 97.—Advanced Stage of Amnion Formation, the Somatopleural Amnion Folds having Come into Contact Over the Dorsum of the Embryo.

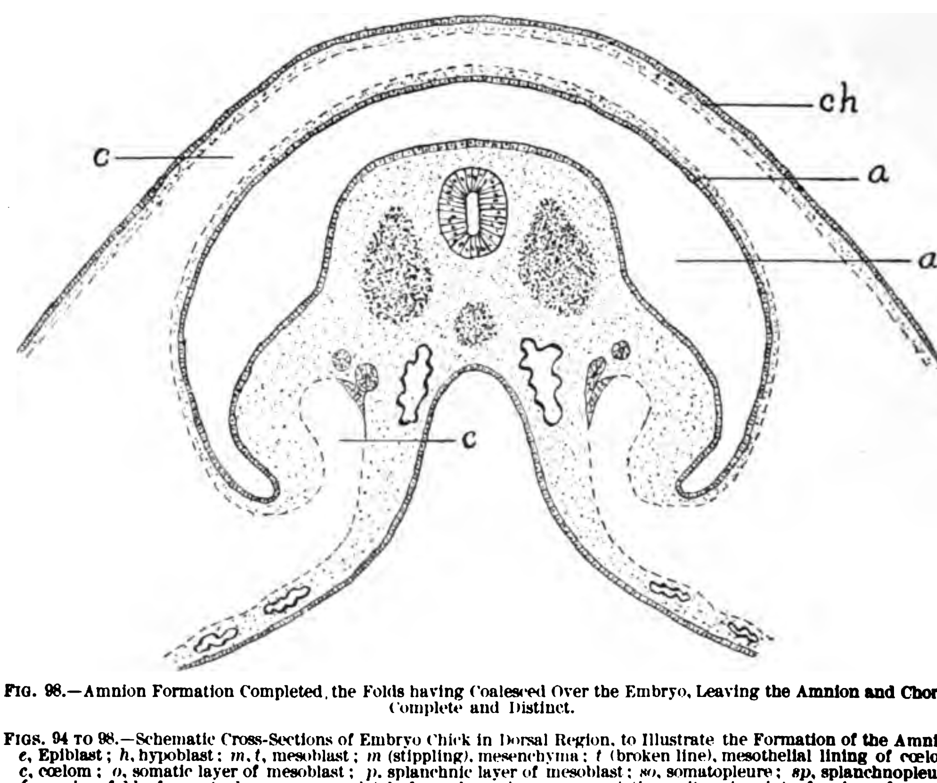

FIG. 98.—Amnion Formation Completed, the Folds having Coalesced Over the Embryo, Leaving the Amnion and Chorion Complete and Distinct.

FIGS. 94 TO 98.—Schematic Cross-Sections of Embryo Chick in Dorsal Region, to Illustrate the Formation of the Amnion. *e*, Epiblast; *h*, hypoblast; *m*, *t*, mesoblast; *m* (stippling), mesenchyma; *t* (broken line), mesothelial lining of cœlom; *c*, cœlom; *o*, somatic layer of mesoblast; *p*, splanchnic layer of mesoblast; *so*, somatopleure; *sp*, splanchnopleure; *f*, amnion fold of somatopleure; *a*, completely formed amnion; *ac*, amniotic cavity; *t*, point of union of amnion folds and site of the "amniotic cord"; *ch*, chorion (or "false amnion"); *v*, primitive vertebra; *n*, notochord; *u*, neural canal; *r*, aorta; *w*, Wolffian body.

formation of the amnion on mechanical principles, but we must probably seek its cause as an evolutionary development of a structure useful to the organism.

The development of the embryos of fishes and amphibia takes place for the most part in water, a medium

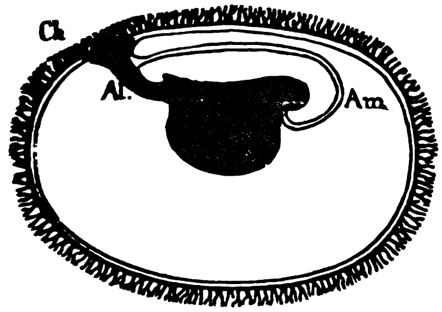

FIG. 103.—Earliest Observed Stage of Human Amnion.

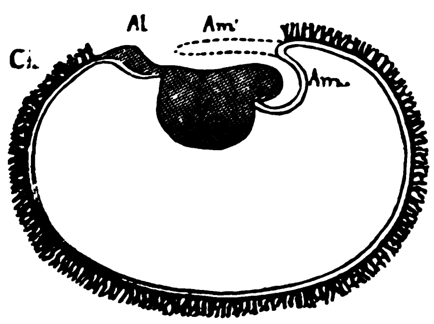

FIG. 104.—Diagram Illustrating His's Theory as to the Formation of the Human Amnion by the Growth Backward of an Amnion Fold from the Anterior Extremity of the Embryo.

FIGS. 103 AND 104.—Early Stage of Human Amnion. *Am*, amnion; *Al*, allantoic stalk; *Ch*, chorion; *V*, yolk sac. (Minot.)

well fitted for the support of a delicate embryo. In the sauropsida and mammalia, on the contrary, development takes place within a rigid shell or the uterus; the development, in these classes, of an amniotic sac filled with fluid in which the delicate embryo is immersed might be regarded as a useful modification by which the advantages of a fluid medium supporting the embryo are secured; or as a contrivance by which the primitive phylogenetic condition of existence in an aqueous environment is retained. The development of an amnion in insects, many of whose ova also develop out of the water, is a fact of perhaps similar significance. The common occurrence of an amniotic membrane in two groups so widely separated as the arthropoda and vertebrata seems to indicate the operation of some deep seated principle.

As already stated, the amnion (in vertebrates) probably first developed in a type just emerging from the amphibian group. A detailed theory of the course of the evolution of the amnion is given by Hubrecht in the work cited above. This authority suggests that the phylogenetic beginning of amnion development may have appeared in a viviparous amphibian, in which an accumulation of fluid occurred in the embryo, forming a vesicle. He regards the mode of amnion formation in the hedgehog (see above) as approximating the primitive and original type, consisting in a splitting off of a layer of the *Deckschicht* over the embryo, and he traces out the various modes of amnion formation in the other amniota as modifications of this type. Some of the placental mammals, according to this view, therefore exhibit the oldest and most primitive method of amnion formation, while the process in the sauropsida and the large-yolked ova of the latter are secondary and more divergent modifications from the original type.

The evolution of the allantois simultaneously with that of the amnion is to be taken into account, and is an obscure and puzzling point. It will be sufficient here to suggest that with the splitting off of the true amnion from the "false amnion" or chorion, this latter outer envelope would remain without any connection with the embryo, and hence would be a useless structure that would soon degenerate. But with the development of an allantois to bring the chorion into vascular and vital connection with the embryo, the chorion would become a useful nutritional structure. Hence the allantois may be regarded as a development complementary or vicarious to the amnion, which saves and puts to useful purposes the chorion.

ANATOMY AND HISTOLOGY OF THE HUMAN AMNION.—The amnion in the fully developed afterbirth is a thin, smooth, translucent membrane lining the inner or fœtal surface of the placenta and membranes. It rests upon the chorion, to which it is loosely attached—so loosely that it has some play on the chorion and can be easily stripped off. At the placental insertion of the umbilical cord the amnion merges into the integumentary covering of the cord, which, while corresponding to the amnion, differs from the latter in some important particulars.

The amnion is made up of two layers: (1) a superficial epiblastic epithelial layer, and (2) a deeper mesoblastic connective-tissue layer.

1. The inner free surface of the amnion, that directed toward the fœtus, is lined by a single layer of epithelial cells of epiblastic or ectodermic origin. These cells at an early period are thin, but later become thicker, low columnar or cuboidal in form. At times, however, in the mature state they appear thin and squamous. The measurements of the dimensions of these cells (diameters or diagonals) given by various observers vary from 0.008 to 0.012 mm. (Dohrn), 0.011 to 0.019 mm. (Kölliker), 0.011 to 0.014 mm. (Lange), 0.011 to 0.053 mm. (Nichols). The varying sizes of these cells, as stated by different observers, probably depend, partly at least, upon the degree to which the membrane is stretched in the process of preparation for microscopical examination. When hardened by the usual reagents without taking any precautions, the membrane is apt to contract or shrink in superficial extent and at the same time to become thicker, thus giving these cells an appearance of greater thickness and less superficial area; while when stretched on a cork and so hardened, the cells may be unduly stretched and thinned.

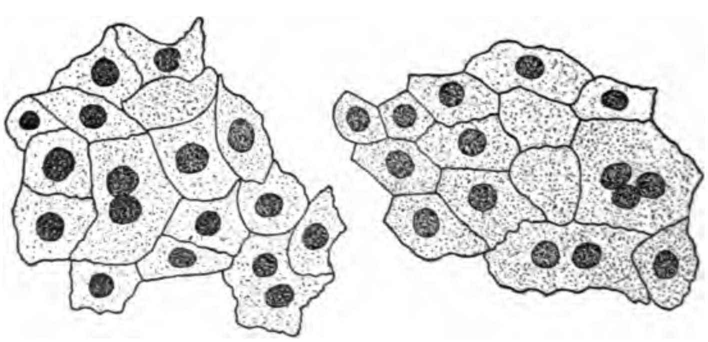

FIG. 105.—Epithelial Cells Lining Inner Surface of the Amnion. Surface view. Silver nitrate and hæmatoxylin. × 1,000.

Viewed from the surface, as after treatment by the silver-nitrate method to bring out the cell boundaries, these cells present the appearance of pavement epithelium, uniting in a single layer edge to edge, with often slightly wavy margins, and being in shape polygonal (often pentagonal and hexagonal), elongated, or irregular (Fig. 105).

Some observers have seen intercellular bridges uniting these cells (Fig. 106).

Viewed in vertical sections, the amniotic epithelial cells appear as low columnar, cuboidal, or thinner cells; the nuclei are often situated near the free ends of the cells, leaving a clearer protoplasmic zone in the deeper portions of the cells (Figs. 107, 110, 111).

The nuclei of these cells are rounded or spherical, about 0.004 mm. in diameter. Most of the cells contain a single nucleus each, but cells containing two, three, or even four nuclei are common; these multinucleated cells are of larger size than the uninucleated. In the latter part of pregnancy the epithelial cells sometimes undergo a certain degree of degeneration. Among these cells are occasionally observed round, clear spaces or objects, which have been variously interpreted as stomata, vesicles, or cells that have undergone mucinous degeneration and burst.

2. Beneath the superficial epithelial layer is a connective-tissue stratum of mesoblastic origin. This stratum

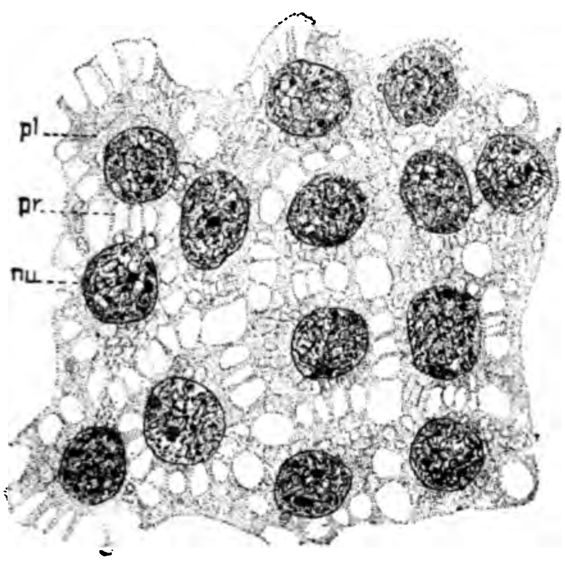

FIG. 106.—Surface View of Epithelium of Amnion from 144-Day Embryo, Showing Intercellular Bridges or Processes (*pr*). *pl*, Protoplasm (cytoplasm); *nu*, nuclei. × 1,225. (Minot.)

can be divided into two layers: (*a*) a thick connective-tissue layer (mesenchymatous), and (*b*) a thin endothelioid (mesothelial) layer lining, partially at least, the outer surface of the amnion, that directed toward the chorion.

(*a*) The connective-tissue layer of the amnion, underlying the epithelial layer, makes up the larger part of the thickness of the membrane, and corresponds to that portion of the mesoblast which has been termed the mesenchyma. This layer is somewhat embryonic in character, and consists of connective-tissue cells embedded in an

FIG. 107.—Section of Placental Portion of Amnion of Two-Months' Embryo. *Ec*, Epiblastic or epithelial layer; *Mes*, mesenchymal (mesoblastic) connective-tissue layer; *Msth*, mesothelial or endothelioid layer. × 250. (Minot.)

abundant matrix. The cells for the most part occupy the deepest plane of the amnion, often leaving in the upper portion of this connective-tissue layer, immediately beneath the epithelial layer, a zone that is free from cells (Fig. 110). The nuclei of these cells are at first rounded and oval, but later become irregular in form and size. The cells are flat and thin, arranged flatwise with the surface. The shapes of these cells, especially in the mature amnion, have not been well made out; one specimen from a mature afterbirth in which the amnion had

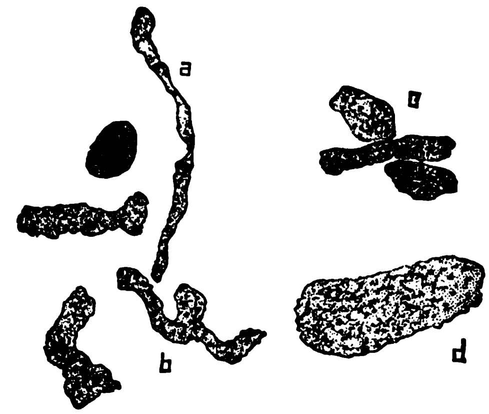

FIG. 108.—Surface View of Nuclei of Mesoblastic Cells of Amnion from Five-Months' Fœtus. × 1,225. (Minot.)

remained permanently separate from the chorion, presenting unusually favorable conditions for observation, has been examined by the writer (Fig. 109). In this instance the connective-tissue cells were mostly large flat cells, very irregular in form, giving off irregular processes and branches, some broad, some fine and filamen-

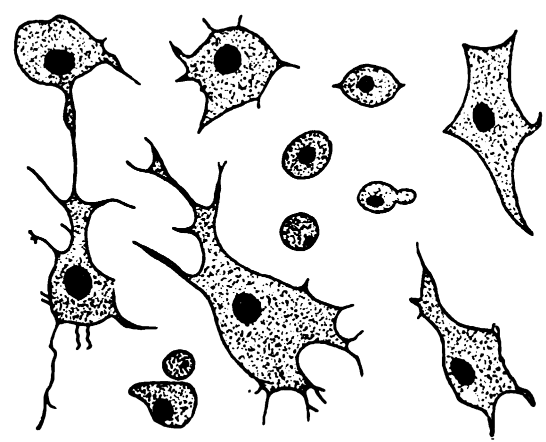

FIG. 109.—Connective-Tissue Cells from Mesenchymatous Layer of the Amnion. Silver nitrate and hæmatoxylin. × 500.

tary. The processes of neighboring cells were often directly continuous with one another. The general outlines of the smaller of these cells were often roughly rounded; of the larger, polygonal or altogether irregular. These cells ranged in size from 0.025 to 0.100 mm. in extreme dimensions, measuring between the extremities of the processes (perhaps the specimen in which these measurements were made was somewhat overstretched). Mingled with these larger cells were smaller rounded or oval cells, not so well provided with processes and ranging in size from about 0.008 to 0.016 mm.

The intercellular matrix in which the connective-tissue cells of this layer are embedded is a homogeneous ground substance said to be of gelatinous or mucinous character. At times, however, toward the close of pregnancy, the deeper portion of the layer (where the cells are mostly situated) becomes markedly fibrous in character (Fig. 110), the outer subepithelial non-cellular stratum still retaining its homogeneous mucinous

nature. The amnion of man is a non-vascular structure and contains no blood-vessels; the presence of an extensive system of lymph channels has not been definitely demonstrated, though such vessels may be present. The amnion of the chick is contractile, and is said to contain muscle cells.

(*b*) The outermost surface of the amnion, that directed toward the chorion, is lined, partially at least, by a single layer of thin, flat endothelioid cells (Figs. 107, 111). These are descendants and representatives of the mesothelial cells which line the cœlom and from which the endothelial cells of the pleura and peritoneum are also derived. These cells are naturally well marked in the early period of pregnancy, while the amnion is still unattached to the chorion and presents a free outer surface. A similar layer of cells probably lines the innermost surface of the chorion. After the amnion becomes united with the chorion, these cells would probably be suppressed at the points of union of the two membranes, though even at full term such cells have been seen at a plane corresponding to the deepest part of the amnion or innermost part of the chorion, perhaps lining spaces left between the membranes similar to lymph spaces in the body lined with endothelium.

In the specimen of afterbirth above referred to, in which the amnion remained permanently separate from the chorion and presented a free outer surface, this layer of cells was nicely demonstrated by the silver-nitrate method (Fig. 112). On surface view these cells were mostly of hexagonal shape (some pentagonal and heptagonal), quite uniform and regular in shape and size, with slightly rounded angles. They were united to one another by their edges, which were straight, not sinuous. Their size was small, measuring 0.0055 to 0.007 mm. in diameter. They did not form a complete lining over the entire outer surface of the amnion, or at least they appeared only in patches; perhaps many of them were lost from degeneration. No nuclei were visible in them—possibly another degenerative sign; if present, they did not take the nuclear stains employed. Patches of precisely similar cells were also observed on the inner surface of the chorion in this case.

FIG. 110.—Section of Placental Amnion from Eight-Months' Embryo. *ect*, Epiblastic epithelial layer; *mes*, mesoblastic connective-tissue layer, showing non-cellular subepithelial stratum and deeper fibrous stratum. × 340. (Minot.)

The covering of the *umbilical cord*, which is continuous at the placental end with the amnion and at the fœtal end with the skin, differs in some marked characters from the amnion elsewhere. This covering consists of a superficial layer of epithelium, which rests directly upon the mucofibrous tissue composing the chief part of the cord. The integument of the cord is therefore intimately adherent to, or an integral part of, the cord, and cannot be stripped off as can the amnion elsewhere. The epithelial covering is composed at first of a single layer of cells, but later becomes stratified squamous in character, consisting of two to four layers of lenticular-shaped cells.

Union of Amnion and Chorion.—In its origin and early period the amnion is distinct from the chorion and separated from it by a space, which is the extra-embryonic part of the cœlom, and is homologous and at first continuous with the pleural and peritoneal cavities. After about the third month of pregnancy, in man, the amnion comes into contact with the chorion, and the two membranes grow loosely together. The precise character of the histological connection between the amnion and chorion has not been well made out.

ABNORMALITIES OF THE AMNION.—Very rarely is the amnion the seat of abnormal or pathological conditions.

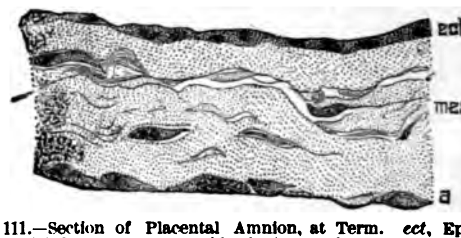

FIG. 111.—Section of Placental Amnion, at Term. *ect*, Epiblastic epithelial layer; *mes*, mesoblastic (mesenchymatous) connective-tissue layer; *a*, mesothelial endothelioid layer. × 340. (Minot.)

Such abnormalities may arise in two ways: from anomalies of development, or from pathological processes.

Among conceivable anomalies of development of the amnion might be: complete absence of the amnion; incomplete development of the amnion from failure of one of the amnion folds to grow; failure of the edges of the amnion folds to unite, leaving a hiatus in the amnion and chorion; persistence of a cord or connection of tissue between the amnion and chorion (the "amniotic cord"), such as normally occurs in ruminants; incomplete expansion of amnion after closure, compressing the fœtus. Some such anomalies of development have been occasionally observed in some animals, but in man they are exceedingly rare.

A couple of human cases are recorded (Hamard) in which there was a separate small amniotic pouch around the abdominal insertion of the umbilical cord. The reporter of one of these cases attributed the condition to a rupture of the amnion (the chorion remaining intact) with retraction of the amniotic membrane. Hamard, who reported the other case, considered the condition to be due in both cases to an early anomaly in the development of the amnion.

It happens, rarely, that the primitive separation of the amnion and chorion persists, in man, throughout pregnancy, so that the fœtus to the time of birth is enveloped in two separate sacs, the amnion internally and the chorion (united to the decidua) externally. This constitutes a rare anomaly of the human afterbirth, of which the writer has reported one case and cited seven other cases found recorded.

Small nodules or caruncles have been observed in the human amnion, scattered about in considerable numbers, some flat and sessile, some more or less pediculated, and ranging in size from that of a pinhead to that of a pea. Structurally, these are of two kinds, one composed of epithelium, the other of connective tissue. The epithelial nodules are commoner and have little or no pathological significance; they are small aggregations of epithelial cells. The connective-tissue nodules are composed of tissue like that of the mesoblastic portion of the amnion; they are very rare, and have been observed in connection with early fœtal death.

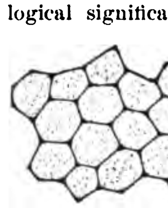
FIG. 112.—Endothelioid Cells of Outer Surface of Amnion (and Inner Surface of Chorion). Silver nitrate. × 1,000.

Adhesions of the amnion to various parts of the fœtus, with resulting deformities of the latter, have been observed. These adhesions have apparently been due to inflammatory action.

Deficiency or excess in the quantity of the amniotic fluid, with the resulting pathological consequences, are considered in other articles.

AMNIOTIC FLUID.—The amniotic sac is filled with a

serous fluid, the amniotic fluid or liquor amnii, in which the fœtus is immersed.

In quantity the amniotic fluid at full term in the human female may vary greatly, but ordinarily ranges from about 500 to 1,000 c.c., averaging from 600 to 800 c.c. Abnormally there may be a deficiency (oligohydramnios) or an excess (polyhydramnios) of amniotic fluid, both conditions giving rise to certain pathological conditions and dangers. The differences in quantity at different periods of pregnancy are not well determined; it is quite possible that the fluid increases in amount during the earlier portion of pregnancy, and diminishes in the later portion.

The liquor amnii is a serous or watery fluid, containing in solution a small proportion of proteid, organic, and mineral substances. It is normally clear, limpid, and transparent, colorless, alkaline in reaction, and has a specific gravity of about 1.007 or 1.008. It contains from one to two per cent. of dry solids, besides a small amount of adventitious epithelial cells, hairs, vernix caseosa, and occasionally leucocytes. Proteids (albumin, globulin, mucin, etc.) are present in the early part of pregnancy in large amount (10.77 per cent. at four months, 7.67 per cent. at five months, 6.67 per cent. at six months), but undergo a great decrease toward the end of pregnancy, when there is only a small proportion present (0.82 per cent.). The inorganic salts present are those usually found in serous fluids, chiefly salts of sodium, potassium, ammonium, and calcium. Urea is present in slight proportion; the amount is less early in pregnancy and gradually increases, 0.03 or 0.045 per cent. being present at the ninth and tenth months.

Marked abnormalities in the physical and chemical characteristics of the amniotic fluid have been rarely encountered.

As to the source from which the amniotic fluid originates, there have been two opposing views: one that it is derived (in mammals at least) from the maternal tissues by transudation from the decidua through the chorion and amnion: the other that it is derived from the fœtus, being the excretory products of the urinary or sweat glands of the latter. The view that the liquor amnii is of fœtal origin has long been held; but in opposition thereto and in support of its maternal origin it has been urged by Minot that the fluid in its composition does not resemble urine, but is more of the nature of a serous fluid transuded from the blood-vessels; that the fluid appears before the urinary or other excretory glands of the embryo are developed and while the urethral outlet of the male is still imperforate; and that substances experimentally administered to the mother have afterward been found in the liquor amnii but not in the fœtal tissues. On the contrary, the fluid occurs in sauropsidan embryos which have lost their connection with the maternal tissues; and as to the finding of drugs administered to the mother in the liquor amnii but not in the fœtus, it is possible that the substances may have been entirely excreted and eliminated from the fœtus and discharged into the amniotic fluid. Possibly in mammals the fluid is derived from both the fœtus and the mother—from the mother at first and later from the urine of the fœtus.

The function of the amniotic fluid is largely to afford protection to the fœtus in utero, by equalizing the pressure on all parts of the fœtal body and preventing undue direct pressure of the uterine walls on particular parts of the fœtus. By maintaining a symmetrical shape of the uterus, and protecting the umbilical cord and uterine walls from excessive and unequal local pressure, it obviates interference with the umbilical, placental, and uterine circulation. The amniotic fluid also permits the movement of the fœtus in the uterus, and prevents adhesions of the fœtus to the amnion or of parts of the fœtus with one another from taking place. The symmetrical distention of the womb by it facilitates and assists in the dilatation of the os uteri during labor. It has been also asserted that the amniotic fluid serves as a source of water for the fœtus; as the fluid contains only a small proportion of solids, it could have little nutritive value except as supplying water. It is well settled that both mammalian and bird embryos swallow amniotic fluid; but whether this is done as a reflex act or for nutritive purposes, or whether the placental circulation is incapable of furnishing sufficient water to the fœtus, is not known. *J. B. Nichols.*

AMNION, PATHOLOGY OF.—The amnion is the innermost of the membranes inclosing the fœtus. It is continuous with the fœtal epidermis at the umbilicus and forms a sheath about the umbilical cord. The exact manner of the development of the human amnion is as yet unknown, for in the earliest embryos examined it forms a complete sac about the embryo. Morphologically, it is a part of the body wall. It consists of two layers: an epithelial one continuous with the ectoderm, and a layer of embryonic connective tissue continuous with the somatic mesoderm. The epithelial layer is on the inside of the membrane, toward the fœtus; the connective-tissue layer on the outside, next to the chorion and uterus wall.

The membrane is thin and translucent, containing no blood-vessels, but is rich in large lymph spaces, forming lacunæ in which the mesodermic cells lie. These spaces are connected by a system of very fine lymphatics. In the earliest stage the tissue of the amnion consists of but two layers of cells (ectodermal and mesodermal), between which lies a distinct space. By the second month these layers have become united, and the mesodermal portion has increased greatly in thickness so that it is capable of being divided into two parts, a thin mesothelial layer covering the chorionic surface of the membrane, and the mesenchyma, which makes up the greater part of the fully developed amnion. The tissues of the amnion do not normally develop beyond an early embryonic stage; the ectoderm preserves its one-layered structure, and the mesodermal tissue remains embryonic in character. No blood-vessels or nerves have been found in the human amnion. In the later months of pregnancy, physiological degenerative changes occur in both mesodermal and ectodermal nuclei.

The amniotic fluid (liquor amnii) is most probably, for the greater part, a secretion of the amnion, but the manner of this secretion or the source of supply to the amnion is still unknown. In the later months of pregnancy some portion of the fluid is undoubtedly derived from the fœtus. It is probable that the fluid is secreted by the capillaries of the chorionic villi next to the amnion, and is passed on through the amnion by means of the activity of its cells. The fluid serves as a source of water supply to the fœtus; and, as a mechanical protection against blows, shocks, pressure, etc., it assists in maintaining a uniform temperature, allows room for fœtal movements, and aids in delivery.

During the first two months there is a definite space between the amnion and chorion, but in the third month the amnion is gradually pressed against the chorion, until an agglutination takes place between the two membranes through the formation of a homogeneous fluid or gelatinous matrix containing few cells. This union is always very slight, as the amnion in all normal cases can be readily stripped from the chorion. In the first three weeks the membrane is somewhat removed from the embryo; in the fourth week the rapid growth of the latter almost entirely fills the amniotic cavity. During the second month the membrane enlarges more rapidly, forming a larger space for the amniotic fluid, but after the fourth month it fits more closely about the fœtus, from which it is kept separated by the fluid.

The structure of the amnion is analogous to that of the serous membranes, and there is consequently a close analogy between the general pathology of the fœtal membrane and that of the latter. The tendency toward plastic exudations with the formation of more or less extensive adhesions, changes in the amount and character of the secretion, etc., occur here as upon other serous surfaces. The peculiar function of the amnion and its

close relations to the embryo lead, however, to pathological processes peculiar to itself.

Hæmatoma.—An effusion of blood between the chorion and the amnion may occur as the result of accidental or voluntary trauma, or of diseased conditions of the chorionic villi. Rupture of the umbilical vessels may lead to the formation of a very large blood clot between the two membranes. The small extravasations from the capillaries of the chorionic villi are relatively frequent and have little significance, but large ones may strip the amnion from the chorion over a large area, producing abnormal pressure upon the embryo and alterations in the amniotic secretion. Death of the embryo and abortion may result from these causes, or the pressure upon the amnion may produce adhesions between it and the fœtus, leading to disturbances of development. The small clots are absorbed and replaced by new chorionic villi or fibrous connective tissue, or they may become calcified.

Retrograde Changes.—The placenta and fœtal membranes at term must be regarded as senile structures, and certain retrograde changes must be recognized as a part of their physiological decay. These signs of age in the amnion begin as early as the fourth month, and manifest themselves chiefly by degenerative changes in the mesodermal nuclei, as shown by diffusion of chromatin, hydropic and fatty degeneration. Marked alterations in the shape of these cells occur in the later months, but these changes are probably dependent upon the tension of the membrane.

Fatty Degeneration.—Minute fat droplets are very frequently found in the mesodermal cells of the mature amnion, and are to be regarded as physiological. In retention of the membranes after abortion this change may reach a pathological degree.

Hydropic Degeneration.—This may occur to a limited extent in the mature amnion. In the rare cases of œdema of the chorion the cells of the amnion become hydropic; and frequently, after death of the fœtus, both the cells and intercellular substance of the mesenchyma undergo liquefaction.

Myxomatous Degeneration.—A myxomatous degeneration of the amnion may be associated with a similar change in the chorion. The mesodermal cells become branched, the intercellular substance more gelatinous in character, and small mucin-containing cysts may be formed in the mesenchyma. A hyperplasia of the mesodermal cells may precede this change, and the amnion may be greatly thickened throughout, or villous-like projections into the amniotic cavity may be formed. In very rare cases these may acquire such size that they may be classed as myxomata. These changes are of most frequent occurrence in the earlier months of pregnancy and usually follow the death of the fœtus.

Colloid-like Change.—The mesoderm of the amnion not infrequently becomes homogeneous and hyaline, loses its cells and slight fibrillation, and stains as colloid. The exact nature of this change is not known. It occurs rather frequently after the death of the fœtus.

Hyaline Change.—Portions of the amnion may undergo a proliferation of the connective-tissue cells, leading to the formation of a more mature connective tissue in which fibres are formed. The intercellular substance acquires a true hyaline character and stains rose red with Van Gieson's stain. This sclerosis in a limited degree may be considered as a senile change, but in the normal amnion it is never extensive, and the membrane for the greater part preserves its embryonic character. Any extensive hyaline change must be regarded as pathological. The causes and conditions of occurrence of this change are not known, but it may occur after the death of the fœtus or in connection with syphilitic changes in the chorionic villi.

Calcification.—Small plaques of calcification are not infrequently found at full term upon the inner side of the amnion, most frequently of the placental amnion. These most probably are calcified masses of fibrinous exudate. After the death of the fœtus lime salts may be deposited in the amniotic mesoderm. This deposit may be preceded or accompanied by fatty, myxomatous, or hyaline change. The pathological significance of calcification, either of the chorion or of the amnion, is probably very slight, and the deposits of lime salts found in these structures at delivery, unless very extensive, are to be regarded as senile phenomena.

Hyperplasia.—After the death of the fœtus the amnion may become much thickened from a hyperplasia of the mesodermal cells. The new tissue formed usually undergoes hyaline or myxomatous change or calcification. Localized hyperplasias may appear as new growths. The processes underlying these changes are practically unknown, but hyperplasia of the amnion is associated, at least in some cases, with syphilitic hyperplasia of the chorionic villi.

Amniotitis.—Since the amnion contains no blood-vessels, a primary inflammation in the ordinary acceptance of the term cannot occur in the membrane. But the tissues of the amnion may become involved in changes which are so analogous in character and sequelæ to inflammatory processes that the use of the term Amniotitis may be accepted for practical reasons. Œdema and liquefaction of the intercellular substance of the mesenchyma may occur; fibrinous exudates may take place, leading to the formation of extensive deposits of fibrin on the epithelial surface of the membrane, and to the presence of strings and bands of fibrin in the lymph spaces of the mesenchyma. The gelatinous tissue connecting the amnion and chorion may wholly or partially liquefy, its number of wandering cells may be increased, and in very rare cases pus may be formed between the two structures. In these cases there is also present a small-celled infiltration of the chorionic villi. The umbilical cord may show a similar infiltration. Purulent placentitis is apparently very rare, and no well-studied cases have been reported. I have seen two cases of placental abscess resulting from infection of the placenta through attempted abortion. In these the space between the chorion and amnion contained masses of fibrin and collections of leucocytes; the amnion was swollen and colloid-like, containing fibrin strings and large numbers of leucocytes.

In both of these cases the amnion was involved by extension from the chorion; and it is probable that the fibrinous exudates, which are rather frequently found in and upon the amnion, are the result of primary pathological changes in the chorion or decidua. The existence of a primary amniotitis is yet to be proved. It has been stated that in cases in which the amniotic fluid is absent or greatly reduced in quantity, the friction of the fœtus upon the membrane leads to the formation of plastic exudates and adhesions. It yet remains to be proved that such exudates are the direct result of changes in the amniotic cells.

That fibrinous exudates do occur has been confirmed by numerous observers, but we are as yet at a loss to explain either their etiology or the manner of their occurrence. Through the organization of fibrinous adhesions between the fœtus and the amnion, fibrous bands may be formed which may lead to the production of marked abnormalities in the fœtus. These adhesions may also be formed between the coils of the umbilical cord or between it and the body of the fœtus. Amniotitis is also regarded as one of the causes of hydramnion, the overproduction of the amniotic fluid being explained as of the nature of an acute serous inflammation. The proof of this remains to be established, but the fact that hydramnion and the formation of adhesions between fœtus and amnion have followed traumatic injuries to the mother may be taken as support of this theory.

In the later months of pregnancy the epithelium of the fœtal surface of the amnion may be torn away in strips. According to Ahlfeld, this is the result of fœtal movements, the epithelium being scratched by the finger and toe nails of the fœtus. The amnion may burst in the last months of pregnancy, the ovum being preserved by the chorion. Through the movements of the fœtus, the torn

membrane may be rolled up into bands, which may become entangled with the umbilical cord and constrict it even to the extent of shutting off the fœtal blood supply. Inflammatory changes have not been shown to follow these conditions.

Amniotic Bands and Adhesions.—During the early stages of development of the membrane there may occur total or partial union of the amnion with the developing skin of the embryo. This union may be the result of an imperfect development of the membrane, in that it does not become differentiated from the ectoderm, or fits too closely about the embryo, so that the amount of secretion is not sufficient to separate the amnion from the surface of the embryo. At the points of contact, union through direct fusion or intergrowth may take place; or a plastic exudate may be thrown out which unites the surfaces and later becomes organized after the manner of plastic exudates on any serous surface. It is still an unsettled question as to how far these adhesions between the amnion and the fœtus are to be referred to a primary failure of separation and fusion, or to inflammatory processes; but it is probable that in the majority of cases they are primary defects of development.

These adhesions play a great part in the formation of monsters and malformations, and their teratological importance can hardly be overestimated. Bands and strings of union not infrequently persist at full term, and their connection with the misshapen portion of the child leaves no doubt that they bear a direct causal relation to the malformation. The structure of these bands usually resembles that of the amnion, containing no blood-vessels; and they may be covered with epithelium. In other cases they are to be regarded as prolongations and outgrowths of the fœtal dermis, and contain blood-vessels which arise from those in the fœtal skin. Very frequently the only remnants of these bands at birth are short tags in the skin of the child. These have a structure similar to that of normal skin. Stretching of the adhesions through increase of the amniotic fluid may lead to their atrophy or to the formation of fibrous bands, which contain few cells and no blood-vessels and possess no epithelial covering.

A total adhesion of the membrane to the embryo causes marked disturbances of development of the head and extremities. Partial adhesions occur most frequently at the extremities of the embryo. An abnormal tightness of the cephalic cap may lead to marked malformations of the cranium, brain, or face (acrania, anencephalia, exencephalia, cephalocele, cyclopia, arrhinencephalia, etc.); while abnormal tightness of the caudal cap produces a deficient development of the lower extremities (amelia, phocomelia, etc.). Clefts of the thoracic and abdominal walls, failures of closure of the dorsal and genital furrows, etc., are also associated with deficient growth of the amnion. It is impossible to say to what extent this association is one of cause and effect or merely a coincidence.

If the amniotic fluid increases greatly in amount at an early period, portions of the adhesions may be separated and torn loose, floating in the fluid; or remaining attached at the ends, they may become stretched into fine threads and bands. These may entangle the extremities of the fœtus and affect their development through pressure and disturbance of blood supply, or even cause intra-uterine amputations. The variety of malformations produced in this way is very great. Larger bands of adhesions may divide the amniotic cavity into several chambers, and an over-accumulation of fluid in one or several of these cavities may result in the production of pressure malformations (club-foot, flat-foot, etc.).

Hydramnion (see *Hydramnion*).—The pathology of an abnormal increase of the amniotic fluid remains unsettled. It is evident that a number of factors may underlie this condition. It may be acute or chronic. The latter may be due to pathological changes in the mother (œdema and dropsy from nephritis, cardiac disease, etc.), hypertrophy of placenta and decidua, placental tumors, persistence of chorionic vessels which normally undergo obliteration, abnormalities of the umbilical vessels; or to pathological changes in the fœtus (increased blood pressure, cardiac hypertrophy, obstruction of the ductus Botalli, syphilitic cirrhosis, fœtal tumors, oversecretion of urine, as in the case of uniovai twins, lymphangiomatous conditions of the fœtal skin, etc.). Deficient absorption of the fluid may also lead to an overproduction of the fluid. In some instances, as in syphilis, disease of both the mother and child may contribute to an excessive formation of the fluid. Acute cases following trauma to the mother have been ascribed to the occurrence of an acute serous amniotitis. Other cases of acute hydramnion arise without apparent cause. These cases are most common during the fourth and sixth months of pregnancy.

Oligohydramnion.—A deficient formation of the amniotic fluid may occur, but the pathology of the condition is as obscure as that of hydramnion. It is commonly found in cases in which extensive adhesions exist between the fœtus and the amnion, and in the case of twins in which one sac may present a deficiency of the fluid, the other an excess.

Abnormalities.—A large number of varieties of abnormal development of the amnion have been described. The most important of these, the bands and adhesions, have been mentioned above. Defects of the membrane, total or partial reduplication, formation of multiple cavities, etc., may occur. The ætiology and the manner of production of these are unknown.

Tuberculosis.—Primary tuberculosis of the amnion has not yet been reported. In one of two cases of placental tuberculosis which I have seen, miliary tubercles were found in the chorion just beneath the amnion, which was thickened and adherent, showing small-celled infiltration and signs of connective-tissue proliferation.

Syphilis.—In syphilis of the fœtus and fœtal placenta a hyperplasia of the amnion similar to that of the chorion may take place. This may lead to a general or localized thickening of the membrane, and is associated with various degenerative processes (fatty, colloid-like, hyaline).

New Growths.—Cysts of the amnion have been described. These were small and without clinical significance. They were most probably due to a myxomatous degeneration of the mesenchyma. Small myxomatous projections into the amniotic cavity occur rarely. They are either localized hyperplasias or remains of adhesions which have undergone a myxomatous change. The existence of true amniotic neoplasms is as yet doubtful.

Extra-Uterine Pregnancy.—In extra-uterine pregnancies, either before or after the death of the embryo, the tissue of the amnion may undergo extensive hyperplasia, and become greatly thickened. It may contain new blood-vessels, which penetrate it from the external cyst wall. After the death of the fœtus the entire amnion may become calcified, forming a calcareous cyst wall, from which the mummified fœtus may be easily shelled out (lithokelyphos); or if adhesions exist between the fœtus and the membrane, these may also become calcified, while the remaining portion of the fœtus undergoes mummification (lithokelyphopædion).

Aldred Scott Warthin.

AMŒBÆ PATHOGENIC FOR MAN.—The amœba belongs to the class of the rhizopoda, of the system of the protozoa. The first recorded observation of an amœba pathogenic for man is that of Lambl, who, in 1859, described amœbæ and other organisms in the mucus from the intestine of a child with enteritis.

The amœbæ described as pathogenic for man may be classed as follows: (1) Amœba coli; (2) amœba oris hominis; (3) amœba urogenitalis.

1. The amœba coli, first described by Loesch in the stools of an individual with dysentery in St. Petersburg in 1875, has, within the last fifteen years, been found in the stools, intestinal contents and lesions, peritoneum, liver and lung abscesses, pleura and pericardium, and sputum of man by numerous observers in various parts of the world. It has been found in some or all these lesions in Egypt by Kartulis, Koch, Kruse and Pasquale;

in Greece by Kartulis; in Bohemia by Hlavna and by Epstein; in Austria by Manner, Kovác (patient from Sumatra), and Cohen; in Germany by Nasse (patient from Florida), Quincke and Roos, Boas, Borchart, Roemer, and others; in Italy by Calandruccia, Fenalglia, Vivaldi, Maggiora, and others; in Russia by Massiutin; in France by Peyrot and Roger; in Roumania by Babes and Zigura; in Siberia by Lobas; in England (in patients from India) by Mason and Galloway, Harold, Curnow, Marshall, Windsor, and others; and in Brazil by Lutz; in the Philippines by Flexner and Barker. Since Osler's first case in 1890, cases have been reported in the United States from Baltimore by Lafleur, Simon, Councilman and Lafleur, Howard, Thayer, Preston and Rühräh, Lewis and others; from Texas by Dock; from Florida by Day and others; from Atlanta by Harris; from Charleston by Wasdin; from Birmingham by Wilson; from Virginia by Slaughter, Field, and Johnson; from Cincinnati by Eichberg; from Cleveland by Howard and Hoover; from Philadelphia by Stengel, Musser, Klein, Buxton, and others; from New York by Lockwood and others; from Buffalo by Stockston; from Boston by Councilman, Burrell, Strong, Fitz and Gerry, and others; from Columbus, Ohio, by Wilson.

Morphology.—The amœbæ described by Loesch varied in diameter from 8 to 37 μ, and had one or two blunt pseudopodia. The ectosarc was hyaline, but apparent on the putting out of pseudopodia. The finely granular endosarc contained a nucleus 5 to 7 μ in diameter, small non-contractile vesicles, red blood cells, and epithelial cells. Accurate descriptions of the organism have been given by Kartulis, Osler, Councilman and Lafleur, Kruse and Pasquale, Harris, and others. Most recent writers describe amœbæ larger than those of Loesch, from 10 to 50 μ in diameter; Kartulis, indeed, described giant amœbæ with a diameter of from 150 to 222 μ. When at rest the organisms are round or slightly oblong in shape, and show no distinction between ectosarc and endosarc, having the appearance of a somewhat refractive body enclosing clear, pale vacuoles of varying size. Some have fine, and others coarse granules, structures which, according to Councilman, represent fine vacuoles. Harris points out that the organism has a faint green or bluish-green color. A nucleus surrounded by a pale rim, and capable of changing its form, can sometimes be made out in fresh amœbæ. It can usually be demonstrated by appropriate staining methods.

Two kinds of motility are recognized: a progressive movement, and one characterized by the putting out and retracting of pseudopodia. When the latter are protruded, the ectosarc appears as a pale, hyaline, homogeneous substance, less refractive than the endosarc. Kruse and Pasquale distinguish four varieties of amœbæ in stools: (*a*) a form with poorly differentiated, highly refractive protoplasm—found in normal fæces; (*b*) amœbæ containing irregular and usually small granules—not uncommon in dysenteric stools; (*c*) amœbæ the endoplasm of which consists of larger and smaller vacuoles—most common form in dysenteric stools; (*d*) amœbæ containing many foreign bodies.

Quincke and Roos make three classes of amœbæ parasitic for man: (*a*) amœbæ intestini vulgaris, 40 μ in diameter, with large granulations, pathogenic for neither man nor cats; (*b*) amœbæ coli mitis, about the same size and appearance as the above, pathogenic for man but not for cats; (*c*) A. coli Loesch, or A. coli felis, about 25 μ in diameter, with finely granular endosarc, producing dysentery in both man and cats.

It should be noted that amœbæ have been found in the stools of individuals in health or with typhoid fever, and with cholera, by Cunningham, Lewis, Shuberg, Quincke and Roos, Kruse and Pasquale, and others. Shuberg and Quincke and Roos have found amœbæ in the stools of individuals after purging with Carlsbad salts. Here the serum poured into the intestine probably changed the reaction of the contents of the organ from acid to alkaline, and thus permitted the growth and survival of amœbæ reaching the alimentary tract by food or drink.

There are possibly several varieties of amœba coli, some of which are harmless. The form found in association with intestinal lesions usually has fine granulations.

Multiplication.—The amœba coli, like other amœbæ, multiplies by direct division; indirect division has not been observed. The organism is said to pass into an encysted stage, from which amœbæ may again be developed.

Cultivation.—The statement of Kartulis in one of his earlier articles, that he cultivated the amœba coli in straw infusion, has not met with general acceptance, and it has been suggested that he was dealing with the ordinary amœbæ of straw infusion. Celli and Fiocca have cultivated amœbæ from the intestinal contents of various animals and of man in both health and disease, as well as from the female genitalia, and from various waters. As a culture medium, they used a strongly alkalinized solution of fuscus crispus, a sea alga, in water or bouillon. On this solid medium they obtained cultures of amœbæ only slightly mixed with bacteria, and were also able to isolate different varieties of amœbæ. They describe the life history of amœba coli as follows: Amœboid state: the organism is lobular in form with numerous lobular hyaline pseudopodia, and measures from 10 to 80 μ in diameter. The ectoplasm is hyaline, the endoplasm uniform, and contains a vesicular nucleus, which may contain a vacuole. In the resting state the organism is from 1.5 to 2 μ in diameter, of single contour, and uniform, finely granular protoplasm. In the encysted stage, there is a double contour, an inner thick, and outer thin contour, while the cyst contents are finely granular. The cycle of development is given as follows: in from twelve to fifteen hours the organism passes from the encysted to the amœba stage, which usually lasts about forty-eight hours, after which the resting stage begins. After from sixty to sixty-five hours they again become encysted or degenerate.

Beyerinck cultivated on malt gelatin an amœba which he believes identical with amœba coli. The organism grew rapidly, both in separate colonies and as a spreading veil-like growth with marked liquefaction of the media. The latter, he thought, was due to trypsin. Spore and cyst formation were not observed. Multiplication took place by direct division. Schordinger claims to have cultivated amœba coli on hay-infusion agar from dysenteric stools. There is evidence that amœbæ may multiply in the intestinal contents.

Staining Reactions.—Living amœbæ are singularly resistant to ordinary dyes, which they take up very imperfectly. Harris has pointed out a marked affinity of living amœbæ coli for toluidin blue, which in weak aqueous solution stains the endosarc deeply at once, and the ectosarc somewhat slowly, giving a sharp differentiation. The stain also fixes the organisms and preserves their natural forms. Preparations after washing in water and mounting in Farrant's solution are said to keep for months. Both the coarser and finer methods of fixing and hardening amœbæ in fæces and other discharges, as well as in the tissues, have been tried with varying success. Councilman and Lafleur obtained the best results with Flemming's solution and safranin, but also got good pictures with methylene blue after alcohol hardening.

Mallory's differential stain gives excellent results with both pus and tissues, but not with fæces.

Mallory's Method: harden in alcohol; stain sections in saturated solution of thionin; differentiate with two-per-cent. aqueous solution of oxalic acid; wash in water, dehydrate in alcohol; clear in oleum origani cretici; wash off with xylol; mount in xylol balsam. "The nuclei of the amœbæ and the granulations of the Mastzellen are stained brownish red; the nuclei of the Mastzellen and all the other cells are stained blue" (Mallory).

After reviewing the various hardening and staining methods hitherto in vogue, Harris concludes that the internal structure of amœbæ is best shown by staining with Heidenhain's iron alum hæmatoxylin after corrosive sublimate hardening. He proposes a new method which gives excellent results.

Harris' Method: Harden in alcohol or corrosive sublimate, stain first in eosin or benzopurpurin, followed by a weak solution of toluidin blue for twenty or thirty minutes; wash in alcohol for three or four minutes; clear in cedar oil or xylol. Slight washing with alcohol shows the amœbæ stained dark blue with very dark nuclei; by further treatment with alcohol the bodies of the amœbæ take a reddish tinge, the vacuoles are distinct and only the periphery of the ectosarcic stained.

Reaction of Ameba Coli to Variations of Physical Condition and to Chemical Agents.—Extremes of heat have a decidedly harmful effect upon amœbæ. Celli and Fiocca have shown that in the amœbic stage they are killed by exposure to 45° C. for five hours, or to 50° C. for one hour, while in the encysted stage they resist 60° C. for one hour and 55° for four days. They also resist drying in either diffuse light or darkness, and in sunlight for two hundred and seventy hours at 12 to 15° C. While the amœba coli usually loses its motility when chilled, Harris has shown that it is not killed by exposure to a temperature of 0° C. Celli and Fiocca claim that both the amœbic and encysted stages resist 0° C. temperature.

The organism will not grow anaërobically, although it may be found 2 metres below the surface of the ground. In both the amœbic and encysted stages it is killed by the various chemical disinfectants used against bacteria. Solutions of quinine, permanganate of potash, hydrogen dioxide, and other substances used for irrigation of the intestine destroy the life of amœba coli. According to Harris toluidin blue rapidly kills the organism. It is very susceptible to the action of acids, in which it soon dies. It is killed by urine (Harris).

Physiological Characters of Ameba Coli.—This organism is phagocytic to an eminent degree, and commonly contains bacteria (both dead and alive), leucocytes, epithelial cells, red blood corpuscles (either unchanged or in various stages of degeneration). The cultural experiments of Beyerinck and the character of the tissue lesions (as first pointed out by Councilman and Lafleur) produced by this organism suggest that it, like certain other amœbæ, produces and sets free a digestive ferment, which is probably trypsin. The amœba coli exerts a direct dissolving action upon tissues, and *has very little if any positive chemotactic action on leucocytes.*

Lesions Caused by Amœba Coli.—(*a*) *Intestine.*—The intestinal lesions caused by this organism are peculiar and wellnigh characteristic. To Kartulis, and especially to Councilman and Lafleur, belong the credit of establishing amœbic dysentery as anatomically and etiologically a distinct disease. The lesions are most numerous in the sigmoid and descending colon, but commonly involve the rectum, transverse colon, and cæcum. The ileum and the appendix (Harris) may also be invaded. The process is characterized by the formation of ulcers, varying in size from a pin's head to that of the hand, which are usually deep, sometimes round, sometimes irregularly round or oval, or with irregular overhanging or undermined edges. The ulcers are often crater-like, and the tissue may have a peculiar honeycombed appearance (Councilman and Lafleur). The muscular coats, especially in the larger ulcers, are commonly laid bare and often dissected up, forming larger and smaller flaps attached at one side. The serosa opposite the ulcers is often thickened and may be covered with fibrin. In many places—and this is quite characteristic—larger and smaller abscesses are found in the submucosa, under an intact mucosa. These abscesses may communicate with the lumen or with ulcers by means of small openings, through which puriform material may be squeezed. The abscesses may burrow for a considerable distance in the submucosa. Councilman and Lafleur and others have established the fact that the process begins in the submucosa, and involves the mucosa and muscularis secondarily. In severe cases large sloughs may be cast off, and perforation occasionally occurs. Microscopically the walls of the ulcers and abscesses are covered with a granular detritus containing a few round cells, and sometimes a few epithelial cells and polymorpho-nuclear neutrophilic leucocytes. The absence of cellular infiltration, except where evidently due to bacterial mixed infection, is a marked feature of the process. The essential lesions seem to be swelling and disintegration of the tissue, which softens and breaks down. The line of necrosis is usually irregular. The blood-vessels may or may not be dilated and congested. The veins often show aggregations of round cells in their lumina and walls, and the latter may disintegrate and thrombosis may occur. Amœbæ are often seen in the veins, and may be seen penetrating their walls. Obliterative endarteritis of the vessels near the ulcers may occur. The lymph sinuses and lymph vessels often contain amœbæ and may show accumulations of cells. As the process advances from the submucosa toward the lumen, the muscularis mucosæ gives way, and, together with the mucosa, breaks down, giving rise to an ulcer. At the surface the mucosa may be reflected back over itself or may overhang the ulcer. Occasionally ulcers are partly lined with epithelium (Councilman and Lafleur). There is hypersecretion of mucus by the glands near the affected portions of the intestine, and in some glands fatty degeneration of the epithelial cells occurs. The intertubular stroma often shows an increase of cells. Amœbæ may be found in the glands and in the intertubular stroma, whence they make their way to the submucosa, as was first shown by Councilman and Lafleur. They probably pass through the muscularis mucosæ by means of the lymphatics. Amœbæ are found in varying numbers in the ulcers and abscesses, along their walls and often penetrating the neighboring tissue for some distance. When the muscularis is extensively invaded, there is dilatation of the vessels of the serosa, which shows cellular infiltration, fibrous tissue thickening, and even fibrin formation. There is reason for believing that amœbæ may reach the peritoneal cavity without marked lesions of the serosa and without perforation of ulcers. In addition to the typical ulcers above described, Harris found in one case superficial ulcers beginning primarily in the mucosa and involving the underlying tissues secondarily. These ulcers showed no amœbæ. Ulcers may be found in various stages of repair. When they heal, the new-formed scar tissue may contract and cause stricture of the gut.

(*b*) *Liver.*—There are two forms of the so-called tropical abscess of the liver, one with and the other without accompanying dysentery or a history of this disease. Abscesses belonging to the latter class are commonly called "idiopathic." In their gross appearances, distribution, and clinical history the two varieties are identical. Recorded accounts of the histological lesions of the so-called "idiopathic" liver abscess are wanting. The only published case of amœbic abscess of the liver in which dysentery has been excluded at autopsy is Buxton's. A woman, forty-one years old, entered the Philadelphia Hospital, September 14, 1898, and died four days later. She complained of weakness and of pains in the abdomen. There was no previous history of dysentery, but her bowels were loose for four weeks before admission. At autopsy the liver was found to contain four abscesses in the right lobe and one in the left, all filled with yellow pus containing amœbæ. The large and small intestines were apparently normal, and no healed ulcers could be found. The weak points in the case are the lack of microscopical examination of the stools for amœbæ, and of sections of the intestines for possible amœbic lesions too obscure to be seen with the naked eye.

The proportion of cases of amœbic dysentery complicated with liver abscess varies within rather wide limits in the experience of individual observers. According to the statistics of Councilman and Lafleur in 1,429 autopsies on individuals dying of dysentery in India liver abscess occurred in 306, or about 21 per cent. In Algiers, of 1,000 autopsies on dysentery cases, 180, or nearly 17 per cent., had liver abscess. The above figures, however, refer only to the cases of dysentery coming to autopsy,

and represent neither the cases of dysentery which recover without liver abscess, nor those in which the patient has liver abscess and recovers. According to Kartulis, of 500 cases of dysentery, from 50 to 60 per cent. had liver abscess. Of 40 American cases collected by the writer some years since, 18 had liver abscess. I feel sure that this percentage is too high, for it is probable that cases complicated with liver abscess are much more liable to be recognized and reported than uncomplicated cases. Liver abscess may occur in the acute form of dysentery, but is more common in the chronic variety, when its course is often very insidious. The right lobe of the liver is the most common seat of these abscesses, and when the left is affected it is usually in conjunction with the right. The abscesses are usually seated in the upper portion of the right lobe; the lower portion of the same lobe, corresponding to the hepatic flexure of the colon, is next in frequency. In one case (Kruse and Pasquale) an abscess was found in the lobus quadratus. The abscesses may start near the surface or deep down in the organ. They are commonly single, but may be multiple; rarely, however, are there more than two or three. Occasionally they are small and multiple and distributed throughout the organ. Several small abscesses may be grouped about a large one. In size the abscesses vary from microscopic points to large collections of pus occupying as much as two-thirds, or even more, of the organ. The abscess contents usually consist of a reddish-brown, anchovy-sauce like material, which usually runs freely, but which may be of an almost gelatinous consistency. In some cases the material is grayish white and contains masses of necrotic tissue. The abscess walls are usually ragged and necrotic, and, when the process is of recent date, soft and irregular. In older abscesses, beneath the necrotic material, there is a translucent layer of gelatinous material, outside of which there is a fibrous zone of varying width and density. The surrounding liver tissue is compressed and indurated. Scars of healed abscesses may be found in the livers of individuals who have had dysentery. The liver may be of normal size or smaller than normal, but is usually much increased in size. The decrease in size is met with in chronic abscesses, with absorption of the purulent material, and secondary focal and diffuse cirrhosis. The fluid portion of the abscess contents is composed almost entirely of granular detritus, with surprisingly few cellular elements. Fewer cells in the state of granular and fatty degeneration may be seen in the pus of acute abscesses, but are usually absent in chronic cases. Red blood cells, well preserved as well as degenerated, are often numerous. A striking feature is the absence of leucocytes. When these are present bacteria are commonly found. Careful search practically always discloses amœbæ, which may, however, be missed in aspirated pus, which probably usually comes from the central and older part of the abscess. Councilman and Lafleur found amœbæ in the smallest abscesses. The earliest lesions are necrosis and liquefaction of the liver cells, with probably serous exudation from the blood-vessels; few, if any, leucocytes wander in, but red blood cells may be numerous. In larger abscesses, masses of liver tissue, chiefly portal systems, may be found. Amœbæ are numerous at the border of the abscesses in the necrotic material and but rarely extend into the surrounding tissues. They may be found in the capillaries. In larger and older abscesses three zones can be made out: an inner necrotic granular zone, a highly refractive reticulum, and an outer layer of granulation tissue, which varies very much in thickness. The inner zone consists of necrotic material containing amœbæ and a few cells, including fatty liver cells. The outer zone may be poor or rich in cells. Here the blood-vessels are dilated, the liver cells elongated, compressed, atrophied, and pigmented. The capillaries and central areas are often obliterated, and there is a more or less well-marked cirrhosis of the liver tissue about the abscesses. A very striking fact in connection with amœbic abscesses of the liver is the absence of leucocytic invasion, which never occurs unless there is bacterial mixed infection. In general, it may be stated that pus with few or no leucocytes coming from a liver abscess is of amœbic origin. Councilman and Lafleur describe diffusely scattered areas of necrosis of the liver cells unassociated with the presence of amœbæ. In some of these areas, which were always at the centre of lobules, the necrotic cells preserved their form, while in others they were broken up into highly refractive masses, or even into small fragments. These authors attribute these areas to the action of soluble toxic substances formed by the amœbæ in the intestinal lesions, and brought to the liver by the circulation, while the necrosis and liquefaction of tissue in the abscesses are due, they think, to the direct local action of the amœbæ themselves.

Liver abscesses may communicate with various organs and cavities, the most common secondary invasion being through the diaphragm into the right pleural sac, or into the lower lobe of the right lung. When there is sudden rupture of a liver abscess through the diaphragm, or when the amœbic process extends rapidly, the pleura rather than the lung is chiefly affected. When the perforation is gradual, and adhesive inflammation binds the visceral and diaphragmatic pleuræ together, hepatopulmonary abscess results. Thierfelder collected 170 cases of liver abscess, of which 76 opened into the lung and bronchi, 23 into the abdominal cavity, 32 into the intestine, and 13 into the stomach. Of Aghetti's 131 cases, 38 ruptured into the lung. Of 6 cases of which I have records, 3 opened into the right pleural cavity and 2 into the right lung. Hepatic abscesses may rupture into the gall bladder, and when the right kidney forms one wall of the abscess the pus may reach its pelvis and appear in the urine. Kruse and Pasquale found in one case of liver abscess, multiple small pus collections in the spleen, distributed along the branches of the veins. They attributed these to the backward flow of pus from the liver through the portal vein. Flexner has reported a case of perforation of an amœbic abscess of the liver into the inferior vena cava.

(*c*) *Pleura.*—Amœbæ reach the right pleura probably only by extension of liver abscesses through the diaphragm, either by rupture or by gradual extension of the inflammatory process. The pleural inflammation is probably always purulent, and the membrane becomes thickened and covered with a ragged, necrotic material, containing amorphous and fibrillated fibrin, red blood cells, and a variable number of leucocytes. The latter are very numerous if there is bacterial mixed infection. Amœbæ are usually numerous. This amœbic empyema is usually chronic, and the retracted lung is bound down by the thickened and adherent pleura. Pneumo-thorax is rare. The pleural cavity may be distended with pus, which may rupture into the lung or bronchi, into the pericardium or through the chest wall.

(*d*) *Lung.*—The right lung, as previously pointed out, is frequently affected by invasion from the liver. Inflammatory processes of the pleura may also extend into the lung. The lesions in the lung are similar to those in the liver, but Councilman and Lafleur have shown that the changes in the interstitial tissue are more marked in the former than in the latter. The abscesses are usually single, but may be multiple and are generally confined to the lower lobe. The abscesses may open into one or more bronchi, by which they are drained. In this case amœbæ are present in the sputum in large numbers, and in two cases I have been able to make a diagnosis of unsuspected hepato-pulmonary abscess by examination of the sputum. When the left lung is affected, which is rarely the case, it is probably due to aspiration of pus from the bronchi. It is difficult to see why amœbæ are not frequently carried to the lungs from the liver by the hepatic vein; but if this occurs, the amœbæ apparently die before lesions are produced. In the rare cases in which liver abscesses have ruptured into the vena cava, death has occurred before metastatic abscesses could form. Amœbæ, as far as is known, never pass through the pulmonary circulation and cause abscesses in distant

organs. Pulmonary and hepatico-pulmonary abscesses may heal both with and without drainage.

(*e*) *Pericardium.*—The pericardium may be invaded in two ways: (*a*) by direct opening of a liver abscess into the pericardial sac, or (*b*) by extension of the inflammatory process from the pleura or lung, as occurred in one of my cases. This is the only case in which amœbæ have been found in the pericardial cavity. The pericardial lesions were similar to those found in the pleura.

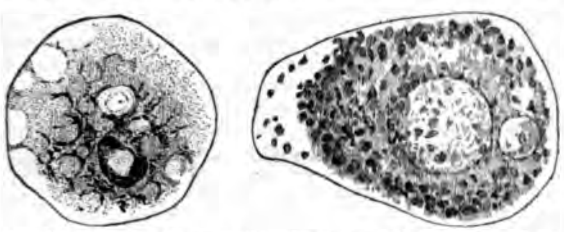

FIG. 113.—Amœbæ from a Section of Intestine. (Adapted from Councilman and Lafleur, Johns Hopkins Reports, vol. ii., plate vii.)

(*f*) *Peritoneum.*—In a few cases localized peritonitis occurs opposite the seat of the ulcers; this may or may not lead to the formation of adhesions. The exudation is sometimes abundant and widespread, of a peculiar gelatinous consistency, and contains numerous amœbæ, with or without bacteria. When intestinal ulcers perforate into the peritoneal cavity, widespread peritonitis occurs, with large numbers of bacteria, as well as amœbæ, in the exudation. Liver abscesses, especially when situated in the lower portion of the right lobe, sometimes rupture into the peritoneal cavity and cause diffuse peritonitis with a gelatinous exudation containing amœbæ. Chronic adhesive peritonitis about the liver, between this organ and the diaphragm, abdominal wall, omentum, and the transverse colon is common. The stomach may be bound to the liver, and abscesses of this latter organ may open into the former.

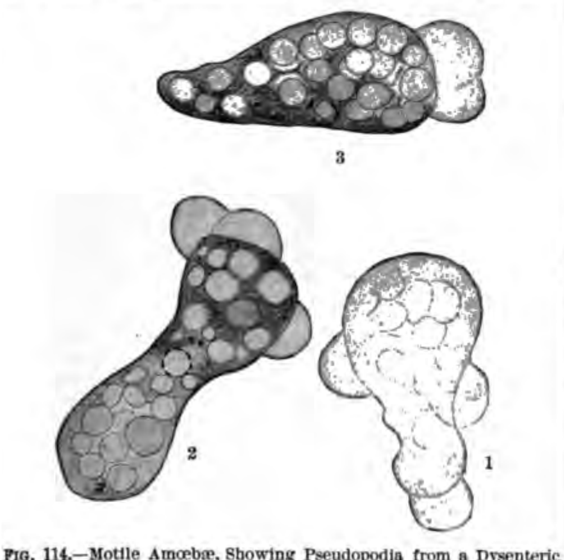

FIG. 114.—Motile Amœbæ, Showing Pseudopodia from a Dysenteric Stool. No. 1 has homogeneous endosarc. No. 2 contains a number of vacuoles and a few red blood corpuscles, and No. 3 contains great numbers of the latter. (Kruse and Pasquale: Zeitschrift f. Hygiene u. Infectionskrankheiten, 1894, Bd. xvi., Pate vi., Figs. 1, 2, 3.)

(*g*) *Changes in Other Organs.*—Fatty degeneration of the heart in amœbic infections has been described by Flexner and by myself. The changes in the kidneys are limited to cloudy swelling and fatty degeneration, except when the right kidney forms part of the wall of a liver abscess. The spleen is usually enlarged, is sometimes soft and sometimes firm, the latter state usually being associated with chronic passive congestion. Reference has already been made to pus collections in the spleen in the case of Kruse and Pasquale.

(*h*) *Modes of Transmission of Amœbæ.*—It is very generally believed that amœbæ reach the liver by means of the portal veins. They are often found in the veins in the intestinal lesions, and, in some cases at least, the hepatic abscesses are widespread and along the distribution of the portal veins. Councilman believes that the organism most commonly reaches the liver by means of the peritoneal cavity, after passing through the intestinal walls, being carried like other foreign particles in this cavity up behind the liver. The lymphatics probably play no part in the transmission of amœbæ to the liver, though the organisms probably make their way through these channels in the intestines and in other organs.

Kruse and Pasquale suggest that amœbæ, like coccidia oviforme, may invade the liver by means of the biliary tract. This would explain the mode of infection in the cases of so-called idiopathic liver abscess. In the case of the idiopathic liver abscesses, it is possible that amœbæ have penetrated the mucosa and submucosa, causing no lesions or at least very slight ones, and have entered the veins and been carried to the liver. Another possible explanation is the presence in the intestine of lesions too insignificant to cause diarrhœa and other symptoms of dysentery. It must also be remembered that constipation is not infrequently met with in cases of widespread dysenteric ulcers. It is very significant that the "idiopathic" liver abscess is most frequently met with in the same countries and conditions in which the dysenteric liver abscess is most common.

FIG. 115.—Section of an Elevated, Deeply Excavated Ulcer, Illustrating Abscess Formation in the Submucosa. *a*, Mucous membrane; *b*, muscularis mucosæ; *c*, submucosa; *d*, muscularis; *e*, peritoneum; *f*, area of cellular infiltration near the ulcer. (Councilman and Lafleur: *Ibid.*, plate i., Fig. 1.)

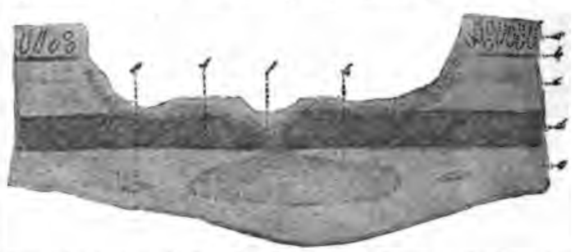

FIG. 116.—Section of a Deep Ulcer Extending Down to the Muscular Coat. The cellular infiltration *g* has extended through the muscular coat at *f*. (Councilman and Lafleur: *Ibid.*, plate i., Fig. 5.)

(*i*) *Association of Other Organisms with Amœbæ.*—In the intestinal lesions, as one would expect, various bacteria ordinarily present in the intestine are found. It seems probable that, in certain cases at least, bacterial invasion of the ulcers and abscesses materially alters the character and augments the severity of the lesions. Certain other animal micro-organisms, such as Trichomonas intestinalis, etc., are sometimes present with amœbæ in the stools. Bacteria have been found in the lung, pleural, and liver lesions by several observers.

Of 13 liver abscesses, Kartulis found the Staphylococcus pyogenes aureus in 2, the albus in 1, the B. pyogenes fœtidus in 1, and B. proteus vulgaris in 1. Councilman and Lafleur found bacteria in the sections of 3 out of 6 liver abscesses. In 7 cases of liver abscess Kruse and Pasquale found streptococci in 3 and staphylococci in 2, and with these they often found typhoid-like bacilli (B. coli?). Flexner found streptococci in 1 case. In one of my cases the Staphylococcus aureus and B. coli communis were found in the pleura, pericardium, and liver. Flexner and Barker found the Staphylococcus citreus in a liver abscess in the Philippines. Kartulis found the Staphylococcus aureus in 4 cases and the Staphylococcus albus in 1 case of "idiopathic" liver abscess, without amœbæ. In 7 cases of this form of liver abscess Kruse and Pasquale found B. pyocyaneus in 2, Staphylococcus aureus in 1, Staphylococcus albus in 1, and typhoid-like bacilli in 1. Amœbæ have not been demonstrated in the so-called "idiopathic" liver abscess, with the exception of Buxton's doubtful case, already referred to.

(*j*) *Presence of Amœbæ in the Lesions. Stools.*—In a large proportion of the cases of dysentery with the peculiar clinical history of "tropical dysentery," amœbæ are readily found in the stools. In a small number of cases they are infrequent, and are found only after prolonged and repeated search, while in a few cases they are not found. Their number and the constancy of their presence must, of course, depend in large measure upon the stage and severity of the lesions. They are readily recognized by their size, peculiar appearance, and movements. In studying the stools, small yellowish gray particles of gelatinous mucus should be picked out. A warm stage is often of advantage, but is not necessary. Warming the slide carefully over a flame will often stimulate sluggish forms to send out pseudopodia. In examining pus from the liver, pleura, and lung, etc., it is important to obtain the specimen for examination from the wall of the abscess rather than from the centre, for the amœbæ are always more numerous about the walls of abscesses. As a general rule, the more acute the process the larger the number of amœbæ present. Amœbæ are found in a very large proportion of dysenteric liver abscesses and of other lesions secondary to amœbic dysentery. They are sometimes missed, especially in chronic cases. Flexner and Barker remark upon their failure to find them in certain cases of dysentery and liver abscess in the Philippines. In the sputum of cases of hepato-pulmonary abscess, amœbæ are usually numerous. In one of my cases numbers were seen in every field of the microscope.

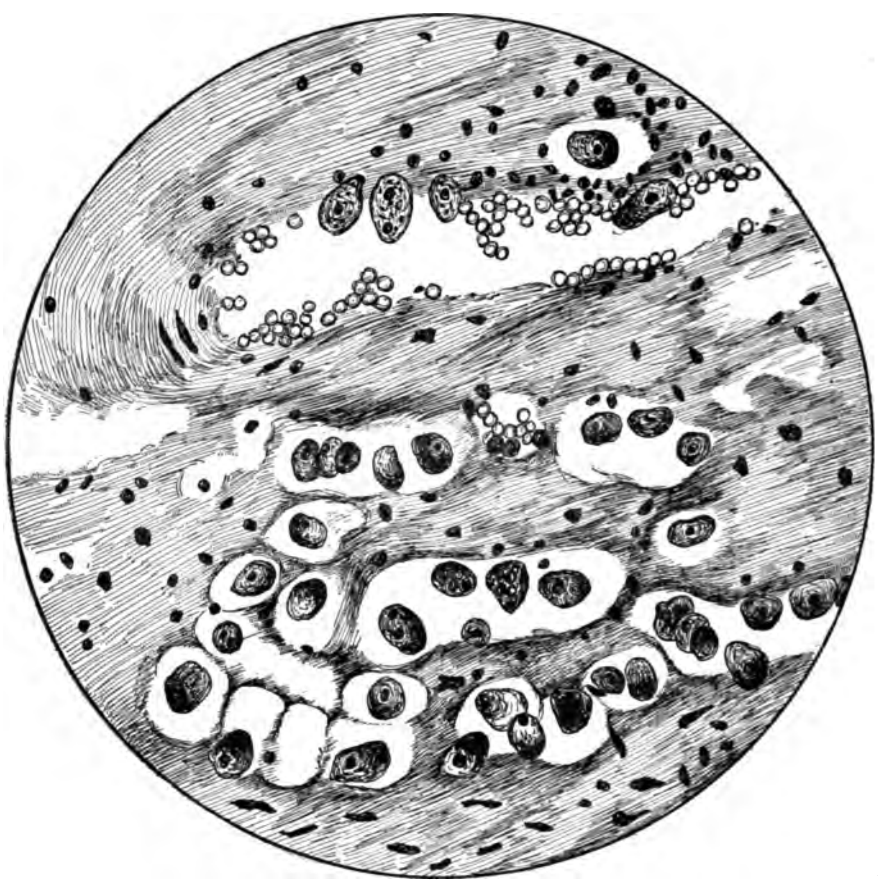

FIG. 117.—Section of Intestine Just Below Ulceration. Beck one-quarter, ocular 3. In upper portion of the field a large vein is seen; the wall of the vessel which is nearest the ulceration is being infiltrated with small cells and is breaking down; both red and white cells and amœbæ are seen within the lumen of the vessel. In the lower portion of the field many amœbæ are seen, some in the tissues, and others in the lymph spaces and lymph channel. (After H. F. Harris, by permission.)

(*k*) *Relation of Amœba to Dysentery and its Complications.*—The chief proofs of the causal relation of amœba coli to these lesions are (1) its practically constant presence in such numbers and in such intimate anatomical relation to the lesions, and (2) the elimination of other micro-organisms as etiological factors. For dysentery, at least, it can be said that there is a special and peculiar anatomical variety associated with the presence of the amœba coli. The disease is a distinct anatomical entity, and in its lesions we find the amœba coli in a relation so constant and so intimate that we are forced to the conclusion that the former are caused by the latter. Inoculation experiments sometimes give positive results, but they are far from constant. Kartulis produced dysentery in cats by rectal injections of amœba-containing stools. Kruse and Pasquale produced well-marked ulcerations of the colon of cats, with numbers of amœbæ in the lesions, by rectal injections of amœba-containing stools and of the amœba-containing but bacteria free pus of a liver abscess. Quincke and Roos produced fatal dysentery in cats by rectal injection of the amœba-containing stools of one case of dysentery. These results are not, however, constant, and objection has further been made that these stools, at least, were not bacteria free. Up to the present time no one has been able to produce dysentery by the inoculation of pure cultures of amœbae grown on artificial media. Although absolute logical proof of the etiological relationship of amœba coli to the lesions in which it is found is lacking, the evidence is almost conclusive, and one is morally convinced of such relation.

(*l*) *Amœba Oris Hominis.*—According to Braun, amœbæ have been found in the human mouth by Gros (*Amœba gingivalis*, 1849), Sternberg (*Amœba buccalis*, 1862), and Grassi (*Amœba dentalis*, 1879). It is extremely doubtful if any of these were of any pathological significance. In 1892 Flexner (*Johns Hopkins Hospital Bulletin*, 1892, p. 104) reported the case of a man sixty-two years of age, previously healthy, who developed a large, tense abscess of the jaw communicating with the mouth. Microscopical examination of the stinking pus which was evacuated by operation showed, besides a variety of bacteria, large numbers of large amœbæ, many of which were actively motile and were not to be distinguished from amœba coli. To quote the author: "In view of the fact that the characters of the amœbæ present in the pus of this abscess and in larger number in the necrotic material found in the pus, resemble in so many respects the amœba dysenteriæ, . . . we are led, in the absence of definite means of distinguishing forms which may have much in common but yet be totally unlike, to regard these as allied species, if not identical." Kartulis (*Zeitschrift f. Hygiene und Infections Krankheiten*, 1893, Bd. xiii., S. 9) reports a similar observation. An Arab, forty-three years old, who had never had dysentery, developed a submaxillary abscess and osteomyelitis of the right inferior maxilla. The mucous membrane of the mouth and gum was swollen, and there was a small fistulous opening into the mouth. The apparent infection atrium was through the alveolar process, where two molar teeth had been lately lost. Pus and sequestra were discharged from the abscess. In the pus, along with numerous bacteria, there were amœbæ with coarsely granular endosarc containing a small nucleus, vacuoles, and red and white blood corpuscles. The pseudopodia were long and finger-shaped. The amœbæ were numerous and measured from 30 to 38 μ in diameter. It is evident that we have at present no positive means either of identifying these amœbæ with or of separating them from amœba coli.

(*m*) *Amœba Urogenitalis.*—In 1883, Baelz ("Ueber einige neue Parasiten des Menschen," *Berl. klin. Wochenschr.*, 1883, p. 237) found large numbers of amœbæ in the bloody urine and in the vagina of a twenty-three-year-old woman with lung tuberculosis. This amœba (which he called *Amœba Urogenitalis*, n. sp.) was very active, and measured in the resting state about 50 μ in diameter, had a granular cell body and a vesicular nucleus. Jürgens (quoted by Braun and by Posner) has described a case of multiple cysts of the mucous membrane of the bladder filled with amœbæ. Kartulis (*loc. cit.*, S. 2, foot note) has reported the case of a man fifty-eight years old, living in Egypt, with profuse hæmaturia and a tumor of the bladder the size of an apple. The urine was dark red in color and contained, besides red blood corpuscles and bladder epithelial cells, a large number of small amœbæ (12 to 20 μ in diameter), which moved lazily and put out short pseudopodia. The endosarc was finely granular; vacuoles and a nucleus could be made out after staining with methylene blue. Posner ("Ueber Amœben im Harn," *Berl. klin. Wochenschr.*, 1893, No. 28, p. 674) has reported the case of a musician of Berlin who was taken sick with a chill and hæmaturia. The urine was dark red in color, and contained albumin, red and white blood cells, renal epithelium, hyaline, granular, and blood casts, and amœbæ. The latter contained one or more nuclei, vacuoles, and red blood cells, had a granular endosarc, and changed their shape slowly. They were from 28 to 50 μ in diameter. On one occasion forms suggestive of encysted amœbæ were seen. The patient recovered after a few days, and both blood and amœbæ disappeared from the urine. The attacks were repeated twice within five months. Examination of the blood and of the bladder was negative. Posner attributed the symptoms to the presence of the amœbæ, which he thinks reached the kidneys by means of the bladder.

W. T. Howard, Jr.

The list of references given below is not intended as a complete bibliography, but includes most of the important articles.

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Beyerinck: Centralbl. für Bakteriologie, Bd. xix., S. 258.
Celli und Fiocca: Centralbl. f. Bak., Bd. xv., S. 470; ibid., Bd. xvi., S. 327.
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Councilman and Lafleur: Johns Hopkins Hospital Reports, 1891.
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AMPUTATION.—Amputation (*amputare*, to cut away) is a term generally used to designate the removal by surgical operation of a portion or the whole of an extremity. In a wider application the word is still used with reference to separations of other prominent or projecting portions of the body, such as the mamma, penis, and cervix uteri. In this article amputations of the extremities alone will be considered. Older writers, and many of the present time in Germany and France, still further restrict the term amputation to the operative removal of a limb in its continuity, as in amputation through the forearm or thigh, while they designate as "disarticulations," "enucleations," the removal of a member in its contiguity (*i.e.*, through the joint). This distinction is properly ignored by English and American writers, since many operations present combinations of the two procedures (Syme-Pirogoff).

Historical Sketch.—The helplessness of surgeons of ancient times to cope with profuse hemorrhage is generally accepted as the sole admissible explanation of the fact that, for nearly two thousand years, from the time of Hippocrates to that of Paré, amputations were practically limited to the removal by cutting through the dead tissues of gangrenous extremities. The only reference to amputations in the Hippocratic writings is as follows: "In case of fracture of the bones, when strangulation and blackening of the parts take place, at first the separation of the dead and living parts quickly occurs, and the parts speedily drop off, as the bones have already given way; but when the blackening (mortification) takes place while the bones are entire, the fleshy parts in this can also quickly die, but the bones are slow in separating at the boundary of the blackening and where the bones are laid bare. Those parts of the body which are below the boundaries of the blackening are to be removed at the joint as soon as they are fairly dead and have lost their sensibility, care being taken not to wound any living part; for if the part which is cut off give pain, and if it should prove to be not quite dead, there is great danger lest the patient swoon away from the pain, and such swoonings are often immediately fatal" ("Hippocrates," Sydenham, vol. ii., p. 639).

The anatomical labors of the Alexandrian school could not have been without influence on the status of surgery. This we see illustrated in the surgical writings of Celsus, who unquestionably was the first to suggest amputations in the living tissues above the line that separates them from the sphacelus. While he admits that patients frequently succumb during the operation from hemorrhage, there can be no question but that Celsus was acquainted with the great usefulness of the ligature. In his chapter on wounds, he advises that "if these [plugging the wound, compression, and mild caustics] do not prevail against the hemorrhage, the vessels which discharge the blood are to be taken hold of and tied in two places, about the wounded part, and cut through, that they may both unite together and nevertheless have their orifices closed."

It seems scarcely possible that the theory, if not the practice, of surgery could have developed to the position designated, unless a less difficult procedure for the liga-

tion of a bleeding vessel in an open wound had been likewise perfected, particularly in view of the facts that Archigenes had introduced the tourniquet, that every writer of the Greek and Arabian schools makes repeated reference to the use of the ligature for the relief of hemorrhage, and that torsion of bleeding vessels was advised under certain circumstances by Galen, Rhazes, and Paulus Ægineta. It is quite certain, therefore, that the proper management of hemorrhage was not entirely lost sight of even in the darkest period of the history of medicine. Indeed, the indications for amputation seem to have been more elucidated for a time after the labors of Celsus. Thus Archigenes enumerates, among the circumstances which require amputation, "the presence of intractable disease, such as gangrene, necrosis, putrefaction, cancer, certain callous tumors, and sometimes wounds inflicted by weapons" (Syd., "Paul Ægin.," vol. ii., p. 410). Nevertheless, the advanced position occupied by this writer was soon receded from. For a thousand years from the time of the latter authority retrogression was the fate of amputations as of surgery in general. Where recourse to amputations was unavoidable, the most barbarous methods were resorted to. The Arabians operated with red-hot knives. Throughout the dark ages the actual cautery was applied to the bleeding stump, or this was covered with boiling oil, or molten pitch, or sulphur. More cruel than any other was the practice of Guy de Chauliac, who in the fourteenth century bound a cord with sufficient force around a limb to insure its removal by gangrene. While amputations were thus dreaded, until within the last three centuries, alike by surgeons and patients, it is certain that this operation was not called for so frequently as it is now. Lacerations as terrible as those produced by machinery and firearms, which for the most part force the amputating knife into the surgeon's hands, could hardly have been often encountered prior to the discovery of gunpowder and steam.

While Gersdorff, of Strasburg, probably had used the ligature in amputation wounds for some years, it remained for the genius of Paré to give to amputations a comparatively firm position among surgical operations. After nearly thirty years of experimentation and practical test of the ligature, he published results which should at once have revolutionized the surgical practice of the time. With the retraction of the skin and soft parts above the site of operation, to insure sufficient tissue to cover the divided bone, and the use of a constricting band, Paré had adopted all the preliminary means which are deemed necessary to-day by many for making a circular amputation. Grasping the open mouths of the arteries with curved forceps, he closed them with a double thread, and the wound with three or four sutures. Likewise was Paré the first who clearly taught the value of the ligature *en masse* in refractory hemorrhages. "Inspired by God with this good work," it would seem that Paré should have speedily moulded the practice of his contemporaries. That this was not the case is evident from the great opposition encountered by him, and that it required nearly two centuries for the ligature to supplant the actual cautery as a hæmostatic measure. Although Fabricius Hildanus in Germany, Dionys in France, and Richard Wiseman in England (last half of seventeenth century) make mention of the ligature, they in nowise recommend it. It is not remarkable, therefore, that in the seventeenth century, Botal did not hesitate to perform amputation by means of two hatchets, one placed immediately below the member and the other loaded with leads let fall upon it (Velpeau, "Operat. chir."), and that even as late as 1761 W. Sharp saw cause for complaint at the restricted practice of ligaturing bleeding vessels. Indeed, it is questionable whether the ligature of vessels in amputation wounds could even then have obtained a firm foothold without the assistance given to it by the tourniquet. The origin of the latter is enshrouded in mystery. There can be no doubt that H. von Gersdorff made use of constricting bands. It appears that the idea of provisional compression of the artery, as now practised, was introduced independently by two surgeons of different countries at about the same time. Morel, in France, and Young, in England, each devised a tourniquet for the arrest of the circulation. It remained, however, for the great J. L. Petit (1718) to elaborate the principles of arterial compression and to construct an instrument from which those now in use differ but little. Finally, with the introduction of digital compression and the use of the Esmarch bandage, the appliances for the control of hemorrhage appear as perfect as human ingenuity can make them.

The most dangerous feature of an amputation being controlled, attention could be directed toward the securing of a more rapid cure and a useful stump. When, in ancient and mediæval times, an amputation terminated well, a year elapsed before the wound had healed, and a conical stump usually resulted. In 1678 a friend of Thomas Young expressed his great surprise that larger extremities could be removed in such a manner that the wound was firmly cicatrized by first intention in three weeks. The circular incision for amputations being the one most quickly accomplished and intuitively resorted to by the earlier operators, was the one generally adopted. Although Celsus clearly indicates the necessity of completely covering the ends of the bone with the soft parts by dividing it upon a higher level, yet it was but rarely accomplished. This will not appear remarkable when we consider how the operation was described as late as the sixteenth century by Hans von Gersdorff, the great barber-surgeon of Strasburg: "And when you will cut him, order some one to draw the skin hard up, and then bind the skin with your bleeding tape tight. Next tie a simple tape in front of the other tape in such a way that a space is left between the two tapes of one finger's breadth, so that you may cut with the razor between them. In this way the cut is quite reliable, goes easily, and makes a perfect stump. Now when you have done the cut, take a saw and separate the bone, and after that undo again the bleeding tape and order your assistant to draw the skin over the bone and the flesh, and to hold it hard in front. You should have a bandage ready of two fingers' breadth; it should be moistened beforehand, so as to be wet through, then bind the thigh from above downward to the cut, that the flesh may protrude in front of the bone, and then bandage this too." Amputation by a single circular incision down to the bone has since been revived by Louis and Brünninghausen in the beginning of our century, and has been advised by Esmarch recently in emaciated and exhausted subjects.

Early in the last century J. L. Petit originated the first decided improvement upon the ancient method of practising the circular incision. With the first circular incision he divided the skin and subcutaneous cellular tissue alone, and after reflecting them divided the muscles upon a higher level by a second circular sweep of his concave knife. Cheselden and Sharp in England, and Heister in Germany, independently devised and became adherents of this improved operation, by which the end of the bone could be completely covered. To still further improve the stump Edward Alanson, after the customary circular incision through the skin, sought to give the wound a funnel shape by applying the knife obliquely and dividing the muscles in the form of a hollow cone. Subsequent operators finding, however, that the wound thus made was not conical, but spiral, and that it entailed conditions unfavorable to primary union, this modification failed to get a permanent foothold among recognized operations. A better and simpler means to produce a conical wound was produced by Desault, who, after division of the skin, divided the superficial and deep muscles on different levels by two separate sweeps of the knife.

Meanwhile flap operations had been devised. Although, according to Velpeau and Lacauchie, Heliodorus had described amputation of superfluous fingers by the double flap operation, the knowledge of this method was

entirely forgotten.* R. Lowdham, of Exeter, in 1679, introduced the flap operation for amputation of the leg by making a lateral flap on one side, a semicircular incision on the opposite side completing the operation. The incision was made from without, and included the skin and muscles of the calf of the leg. Although, as already indicated, Young (currus triumphalis) most highly lauded the results achieved by the new method, it was ignored until Peter A. Verduyn, of Amsterdam (1696), practised a similar amputation, transfixing the soft parts with a double-edged knife. Sabourin and Garengeot adopted the method by transfixion. Other modifications rapidly followed the first steps of the new method. H. Ravaton (1750) and Vermale (1767), surgeons of the Palatinate, recommended the formation of double flaps, while Charles Bell (1807) and the elder Langenbeck (Göttingen) again practically returned to the older operation of Lowdham. On the other hand, Sédillot, in 1841, and Teale, in 1858, greatly improved the double-flap operation. Sédillot formed two musculo-cutaneous flaps, in which only a small part of the flesh was included, and divided the remaining soft parts by a circular incision. A number of operators advised that the flaps be of unequal size, lest the cicatrix become adherent to the divided end of the bone. Finally, Thomas Teale, of Leeds (1858), devised the antero-posterior rectangular musculo-cutaneous flaps. Scoutetten, of Metz, in 1827, combined into what is termed the oval method a number of operations which had been previously employed by the elder Langenbeck, Larrey, Guthrie, and others. According to Scoutetten, this method, which is best adapted to disarticulations, is supposed to possess the advantages of both flap and circular operations. While, on the Continent, this operation has found a small band of followers, it has never met with general favor.

INDICATIONS.—Amputation has been termed the "last resource" and the "opprobrium" of the surgeon. Recourse to this radical measure signifies the surgeon's unbelief in his efforts to restore to usefulness an injured limb; it is his confession that, in the combat with disease, he has been conquered, or that his ability to rectify a congenital deformity is limited. To recognize the limits of his powers to save a part requires the keenest judgment of the surgeon, and it is remarkable how, in the history of amputations, this has swayed between the extremes of radicalism and conservatism. It is, of course, not remarkable that, prior to the introduction of the ligature, amputations were, for the most part, confined to the removal of parts which were all but removed by an accident itself, or were already the seat of gangrene. On the other hand, the multiplication of methods of amputation, during the last and the early part of this century, went hand-in-hand with the most reckless condemnation of limbs. The voices of Gervaise and Boucher, which were raised in defence of conservatism, were unheard, and even the remarkable reports of Bilguer were unable to stay the useless sacrifice of limbs. Bilguer, the father of conservative surgery, and surgeon to Frederick the Great, could report, in 1763, 169 compound fractures successfully treated by conservative methods. Among these were 9 of the femur, 42 of the leg, 19 of the ankle, 9 of the head of the humerus, 16 of its shaft, 22 of the elbow, 9 of the forearm, 3 of the wrist, and 3 of the hand. The distinction which these statistics brought to Bilguer was materially dimmed by the fact that he published his successes alone, and that for a while he denied amputations a place among justifiable operations. The incredulity of surgeons in these results and extreme views was one of the causes which prevented them for many decades from restricting the indications for an amputation. Faulty methods of treating wounds and an insufficient appreciation of the dangers attending major amputations were likewise potent factors in so frequently forcing the amputating knife into the hand of the surgeon. The introduction of immovable dressings, the startling statistics of Malgaigne, published in 1842 and 1848, the favor with which excisions were received, and, above all, the advantage of antiseptic treatment in the widest sense, were the chief causes in finally determining the indications for amputations as they are now generally accepted.

In general terms, it is proper to resort to amputation when the sacrifice of a part, which is hopelessly diseased, is necessary to the preservation of life or the enjoyment of its various functions and duties. It is well to remember that "the vast majority of people would prefer living with three extremities to being buried with four." While in each individual case the danger and advantages of an operation are to be carefully balanced, conditions may arise which may make an operation imperative which but a few days before seemed uncalled for.

Contra-indications to amputation, either temporary or permanent, should also be clearly recognized. Among the former, particularly as to amputations for injury, should be considered extreme shock and exhaustion from excessive hemorrhage. As permanent contra-indications, such conditions should be recognized as will preclude the possibility of attaining the object of all operative procedure, viz., the restoration of the patient to health. Such indications are, first, so extensive an involvement, by disease, of a limb and contiguous parts that amputation will not suffice for its complete removal, and, second, complications on the part of important internal organs from injury or disease, under which circumstances an amputation would not only be useless, but would probably curtail life.

While it is an axiom that amputation should be resorted to only under circumstances in which no other means will avail, there is no little difficulty in determining the conditions that call for this extreme measure. They may be most readily investigated by considering them under the three general headings of injuries, non-traumatic lesions, and deformities.

INJURIES.—(*a*) When, from accident of any kind, a limb is entirely severed from its connection, or the soft parts so mutilated that it is attached by skin alone, or by it and pulpified flesh, an amputation is absolutely indicated. Wounds from circular saws, railroad accidents, extensive gunshot lacerations, afford numerous instances in which the amputation consists in nothing more than trimming off the ragged edges of the wound, levelling the inequalities of the protruding fleshy masses, and placing the stump in the best condition for speedy repair. To this class of injuries belong those cases, caused by railroad trains, heavily loaded wagons, entanglement in machinery, etc., in which the soft parts are extensively torn from the bone, the muscles being pulpified, the blood-vessels and nerves lacerated. It is remarkable that in instances of this character the skin itself may remain unbroken, while all that it covers has been practically crushed. The shock attending the tearing off of a leg or an arm is usually so excessive that a formal operation with attendant loss of blood must be dispensed with.

On the other hand, it is a well-established fact that fingers, portions of the nose and ear which had been almost completely and even totally separated by an incised wound uncomplicated by contusion, have been permanently replaced by the careful use of sutures.

(*b*) Extensive burns and circumferential lacerations of only the skin and subcutaneous cellular layers may, in rare cases, require the sacrifice of a limb. When, from the depth of a burn, it becomes evident that the reparative process must be suppurative in character, and continue for many months, and when finally ended leave a disfigured and practically useless member, it is usually better at once to amputate than to expose the life of the sufferer to the dangers of septic infection, amyloid degeneration, or exhaustion. Extensive stripping of the integument from a member may likewise impel the surgeon to operative interference. A most interesting case of this character is recorded by M. Schede (Billroth und

* The importance of covering the end of the bone was patent to many—Barth, Maggi, among others (Von K. Sprengel: "Gesch. der Chir.," vol. i., p. 408, Halle, 1805).

Pitha's, "Handbook" vol. ii., Heft ii., 2 Abth., p. 19), in which an entire arm was caught in a cogwheel and stripped of its integument, the muscles of the arm and forearm being laid bare as in a careful dissection. Although amputation at the shoulder was successfully resorted to and the acromion removed, the integument was insufficient for the closure of the wound.

(c) The simultaneous injury of the main artery and vein of an extremity has usually been considered an indication for amputation, since it almost invariably results in its mortification if conservatism is practised. This has applied particularly to wounds of the femoral artery and vein. The advisability of an operation in all such cases must, however, be seriously questioned, since instances are multiplying in which with neoplasms, several inches of the main vessels of the limb have been removed without resulting in its death. When the vein alone is slightly injured, it is far preferable to trust to a properly applied lateral ligature, or if it is completely divided, an attempt to save the limb should be made by ligation of the accompanying artery. Quite recently a case has been recorded by Pilcher in which an incised wound of both femoral artery and vein was successfully treated by double ligation of both vessels. On the other hand, amputation may be required for the relief of traumatic aneurisms or those of spontaneous origin which have become diffused. Particularly may ablation of the thigh be preferable to other plans of treatment of aneurism of the popliteal and of the deep arteries of the leg in persons of advanced years. In cases of subclavian aneurism exarticulation at the shoulder has likewise been successfully performed as a modified distal ligation. Finally, secondary hemorrhage after injuries from whatever cause, when other measures have failed, can be relieved alone by the sacrifice of the limb. Since, after ligation in continuity of an artery, the secondary hemorrhage most frequently comes from the distal end of the vessel, it is apparent why amputation is often successfully practised.

(d) Compound fractures and dislocations are the conditions which most frequently call for amputation in all communities where manufacturing interests are largely developed and where railroads furnish employment to large numbers. Not very long ago, the presence of a compound comminuted fracture was deemed sufficient cause for an amputation, even if unattended by extensive laceration of the soft parts. In no field of surgery have greater triumphs been recorded than in the conservative treatment of these compound fractures. There can be no question but that to-day all surgeons of twenty years' experience save limbs which in their earlier experiences they would have doomed. For these results we are in the main indebted to the principles of antiseptic treatment, which, although first promulgated in 1865 in Glasgow by Mr. Lister, were first extensively practised on the Continent, especially in Germany, by Bardeleben, Volkmann, and Nussbaum.

It is immaterial for our purpose which of the numerous antiseptic agents be preferred, or whether the open method of wound treatment with thorough drainage be employed. Such remarkable results have been achieved in the conservative treatment of compound fractures that ordinary cases may be said to present no indications for amputation. Nearly a year ago a lad of eighteen had his left arm caught in the belt of a wheel in a machine-shop. When brought to the Good Samaritan Hospital, in Cincinnati, an hour after the accident, there was detected a double fracture of the humerus, one of which was compound, a simple dislocation backward of the elbow, a compound fracture in the middle third of the radius with two inches of fragment protruding, and a compound dislocation of the ulna at the wrist. An amputation was strenuously advised, but, fortunately, it was rejected by the parents. The boy, after confinement for nine months, recovered after two inches of the radius and six inches of the ulna had been removed. The hand and forearm are almost useless, but this condition is infinitely preferable to that of being obliged to wear an artificial limb, no matter how perfect it may be. In his service at the Cincinnati Hospital the writer recently saw a negro with a cog-wheel crush of the ulnar half of the wrist and metacarpal bones, and of the upper third of the humerus, and pulpifying of the overlying deltoid. The removal of the upper third of the humerus, including its head, and of the crushed bones of the carpus and hand, and the establishment of ample facilities for drainage, left the man with good use of forearm and three fingers. Particularly in injuries of the upper extremity is conservatism commendable.

Statistics of the advantages of conservatism in the treatment of these accidents are rapidly accumulating. Thus, Volkmann was enabled to report 75 compound fractures of the larger long bones without a single death, although in 8 cases he was compelled to resort to secondary amputation. Sir Joseph Lister, with rigid adherence to the antiseptic method, lost 2 out of 97 cases. In the treatise of Billroth and Luecke is a most exhaustive compilation of 254 cases which were treated by the Listerian method. Of 224 of these cases which were treated conservatively only 14 died. But it remained for our own countryman, Dr. Fred. S. Dennis, to record the most brilliant and, indeed, unique successes ever obtained in this field. Of 144 cases of compound fracture treated in Bellevue Hospital, New York City, not one died from septic infection, and 100 cases were treated without a death from any cause. Extensive splintering of bone and laceration of soft parts can, therefore, no longer be considered an excuse for the sacrifice of the limb. If amputations still form a considerable percentage of the operations performed in large hospitals, it is because of the more extensive employment of heavy machinery, and the great extent of railway travel. Most of the primary amputations thus practised are indicated by the conditions above detailed (sub *a*).

(e) Closely allied to compound fractures in their relation to amputations are compound dislocations. Since the more general appreciation of the value of primary excision of joints, amputations for these injuries are now less frequently resorted to than formerly. Indeed, all formal operations for compound dislocations should be greatly restricted. Cooper and Nélaton already leaned toward conservatism. The latter advised reduction of the dislocation, closure of the external wound, and antiphlogistic measures. What has been accomplished in this way in recent years, and particularly by immobilization, could be demonstrated by a stately array of cases of compound dislocations of large joints in which the limb was saved, and often with perfect motion. Compound dislocations of shoulder, wrist, hand, and elbow, unless the damage of the soft parts is such as *per se* to call for amputation, should always be treated without operation, or by excisions. A compound dislocation of the elbow, with laceration of the brachial artery, was successfully treated without operation by McCarthy, and Davis reports another such dislocation of the knee, in which all the functions of the joint were retained.

On the other hand, amputations for compound dislocations of the foot and ankle are more frequently indicated, since excision and conservative measures often leave the parts useless, if not positively a burden, and the dangers of primary amputations are at least no greater than those which attend milder methods of treatment of these cases.

(*f*) *Gunshot Wounds.*—These are of sufficient frequence in civil practice often to call for amputation. Here, on account of suitable accommodations and facilities for proper treatment, conservative means may be adopted, whereas in the field a part must be sacrificed for the benefit of the whole. Revolver wounds of the large vascular and nerve trunks, with shattering of the bones, may necessitate amputation. Shotgun wounds, from the greater laceration inflicted, particularly in the neighborhood of the larger joints, may require the sacrifice of a limb. Nevertheless, with our better methods of wound treatment, the surgeon should even here lean toward conservatism. The writer has recently saved a lower and

an upper extremity by a typical resection of the knee and shoulder in cases of gunshot wounds sustained at close range.

Before the introduction of small-calibre projectiles Connor enunciated the conditions calling for amputation as follows: 1. When there has been great destruction of soft and hard parts, as in a crush by large shot, or when the limb has been almost completely or altogether carried away. 2. When the fracture is associated with laceration of the main vessels or nerves of the part. 3. When acute, infective osteomyelitis has been developed. In the chronic form of this disease, when the entire length of the bone has become affected, it may or may not be necessary to amputate, according to the general condition of the patient and the particular bone that is diseased. 4. When there is severe secondary hemorrhage from an eroded vessel, or from a ruptured traumatic aneurism. 5. When gangrene has supervened.

The small calibre of the modern rifle ball has so modified wounds sustained in action that amputations are but rarely demanded. Furthermore, the thorough curetting of the medullary canal in acute osteomyelitis when it has developed, tends still further to limit the scope for amputation. Secondary hemorrhage from an eroded vessel or the rupture of a traumatic aneurism should, in the light of our better methods of the treatment of wounds of vessels, not be considered an indication for amputation until search for the wound and ligation have been tried without success.

(*g*) *Mortification.*—The presence of mortification, as a sequel of trauma or of the application of the extremes of heat and cold, offers an unmistakable indication for the ablation of a part as soon as the evidences of the limitation of the gangrene are made manifest. Nor is it always advisable to wait for this in the case of traumatic gangrene, which often extends with such rapidity that a few hours will rob the sufferer of his only chance. The mortification which follows the ligation of an artery, or upon an embolism, is a condition calling for operative interference. In senile and diabetic gangrene amputation is often demanded. Amputation should be performed far from the gangrenous area. In the first-named form of gangrene, as of the foot or part of it, the amputation must be made at or, better, above the knee. In both forms of gangrene amputation, to be successful, must be performed before secondary and general infection has taken place from about the gangrenous field.

(*h*) *Tetanus.*—Amputation may be said to be one of the most successful measures for the relief of traumatic tetanus (when thorough curetting of the wound has failed to relieve). According to the latest experiences an equal proportion of good results follows this method and nerve section. The latter should be given the preference in every case; and then, in the event of failure, amputation should be resorted to as a *dernier ressort.*

Non-traumatic Affections.—(*a*) *Inflammation.*—Severe and extensive inflammations of the skin, subcutaneous cellular layer, and intermuscular layer, as they are frequently encountered in phlegmonous erysipelas from injuries which in themselves are most trivial, and which from septic infection or protracted suppuration would lead to death, are conditions that may necessitate an amputation. While with free incisions, the permanent water dressing, and irrigation, many limbs thus affected may be saved, amputation must always be resorted to in a certain small proportion of especially aggravated cases. The presence of septicæmia and pyæmia should not be deemed a contraindication, unless the want of vitality of the patient will preclude the possibility of surviving the shock resulting therefrom. Billroth, Volkmann, Fayrer, Weinlächner, Luecke, and numerous other surgeons cite cases in which amputation was successfully practised after a varying number of rigors had placed the presence of the gravest constitutional infection beyond doubt. By removing the primary seat of the septic changes, the general manifestations of pyæmia may frequently be caused to disappear.

(*b*) Inflammatory conditions of the bones and joints which cannot be relieved by less radical measures often make an amputation imperative. Acute spontaneous osteomyelitis, when unrelieved by trephining, and when affecting only a single bone, must be considered a condition requiring this radical interference. Necrosis which involves the entire thickness of the shaft of the bone, as for example a part of the humerus, or the femur, and especially when repeated necrotomies have proved to be unavailing, occasionally requires the sacrifice of a limb. In extensive caries of the articular ends of the long bones, or of the carpus and tarsus, when from the depraved condition of the patient excision is unfeasible, amputation is compulsory. The improved methods of dealing with suppurative and destructive affections of joints by immobilization, and, if need be, by resection, have happily reduced the number of cases calling for amputation from these causes to a minimum.

(*c*) Extensive circumferential ulcerations of the leg, which sap the strength of the patient through hemorrhage or profuse suppuration, or which unfit him for the vocations of life, not unfrequently render amputation advisable. This also applies to cases of true and spurious elephantiasis, in which milder measures have proven of no avail.

(*d*) Tumors of benign and malignant character, when from their size they destroy the usefulness of a limb or endanger life, are well-recognized indications for amputation. The neoplasms most frequently demanding the latter are carcinomatous degenerations of chronic ulcers or epitheliomata developing around a sequestrum, or an osteosarcoma of the articular ends of the long bones. Under all these conditions amputation offers a better chance for permanent recovery than does excision.

The rule which applies to the management of neoplasms generally, that an operation must be refrained from unless all of the diseased tissue can be removed, is particularly to be remembered before an amputation is determined upon for the relief of a tumor of an extremity. The bearing of amputation upon certain traumatic affections of the blood-vessels and upon special spontaneous aneurisms has already been referred to. Congenital telangiectases likewise exact amputation when rapidity of growth endangers life or when other plans of treatment have been unsuccessful.

Deformities.—(*a*) Supernumerary fingers and toes are proper cases for removal, and the operation may be safely practised six months after birth. This early removal assures a better form of hand or foot and a diminutive scar. Cases of club-foot which have been altogether neglected or badly managed, and which, from extensive ulceration or inflamed bursæ, entail great suffering upon the patient, not infrequently can be relieved by amputation only. But in early life no case of talipes is of sufficient severity to warrant the removal of the foot.

(*b*) Cicatricial contractions of the joints, associated with great wasting of the muscles, from extensive burns; great deformity and uselessness of a limb from neglected dislocation (foot or ankle), may call for an amputation. For these and similar cases, amputations of expediency may occasionally be required, but the surgeon should carefully weigh all factors in the case before subjecting his patient to the risks of an operation for the relief of a condition which in itself is only a burden and not a source of danger. To this category belong limbs useless below the knee from infantile paralysis. Such legs are often burdensome from one cause or another (sensation of cold, proneness to superficial ulceration, etc.) and, since they are useless, it is probably better to amputate them and substitute an artificial limb.

Time for Amputation.—When, in consequence of an injury, an amputation is indicated, the proper time for performing it must be considered. While the patient is still suffering from shock, collapse, or even exhaustion from excessive hemorrhage, it would be sealing his fate to resort to an operation. At least moderate reaction must invariably be awaited, irrespective of its early or late appearance. When reaction has once been established, with the aid of restoratives (among which

the intravenous injection of normal salt solution ranks first), the most appropriate period for an amputation will have arrived, since, for a period varying from twelve to seventy-two hours, the injured part remains in apparently the same condition that it was in immediately after the accident. After this interval, there may be expected to supervene those local and systemic manifestations in the injured part which belong to severe inflammatory changes. All amputations practised prior to the advent of these changes are designated *primary amputations*. Since the time when these changes supervene varies from one to three or four days, according to a multitude of circumstances, foremost of which is the character of the wound and the extent to which it can be maintained aseptic, no absolute limit can be fixed to the time when an amputation should no longer be classed among the primary amputations. With very few exceptions, surgeons of the present day recognize the necessity of immediate amputation in every instance in which conservatism cannot be practised. The diversity of opinion which has prevailed on this subject has been great. Among the advocates of primary amputation may be enumerated Du Chesne, Wiseman, Pott, Percy, J. Bell, Larrey, and Guthrie; among its opponents, Faure, Hunter, and, within the last quarter of a century, J. Neudörffer, Paul, and Gross. The extensive experiences of Guthrie and Larrey have finally convinced surgeons of the advantages of early, as compared with late, amputations. Of 291 primary amputations, 107 recovered, 24 died, and 160 remained under observation. Of 551 secondary operations, 170 recovered, 265 died, while 116 remained under treatment (Guthrie). The accumulated experiences of the Crimean and Franco-Prussian wars, and the vast statistics of our Civil War, indorse the prevailing practice of resorting to early amputations. In the statistics of Otis, there were in 3,259 primary amputations of the arm, 602 deaths, 18.4 per cent. mortality; in 902 intermediary amputations of the arm, 302 deaths, 33.4 per cent. mortality; in 411 secondary amputations of the arm, 114 deaths, 27.7 per cent. mortality; in 1,914 primary amputations of the lower third of the thigh, 927 deaths, 48.7 per cent. mortality; in 676 intermediary amputations of the lower third of the thigh, 459 deaths, 67.9 per cent. mortality; in 207 secondary amputations of the lower third of the thigh, 100 deaths, 48.3 per cent. mortality. The obvious reasons for the better results which follow early operations are that they are made at a time when the constitution has not yet been exhausted by protracted suppuration and high temperatures, and that they leave wounds which can be kept free from septic infection.

The second date at which an amputation might be forced upon the surgeon is that during which the severest local and general signs of inflammation present themselves. The damaged limb has become red, œdematous, and painful. From the wound there issues a sanious, malodorous fluid, and a more or less extensive sloughing of the tissues adjacent to the wound ensues. Associated with these local conditions are an acceleration of the pulse, elevation of the temperature, often to a dangerous degree; headache, dry tongue, scanty urine, and muttering delirium. Unless the patient succumbs to the paralyzing influences of excessive temperatures, his condition becomes gradually ameliorated in from five to fifteen days. As the discharge of scanty serum is followed by a free secretion of pus, the gangrenous parts are exfoliated, and the swelling largely subsides; the fever and acceleration of pulse are reduced; the tongue regains its normal moisture and color, and a comparative degree of comfort is enjoyed. Amputations practised during this stormy period of the clinical history of an accident have, after the designations of Boucher and Alcock, been called *intermediary*. Since they are made at a time when the damaged part and the system at large are in the very worst condition for operations, it is not remarkable that such amputations offer the worst prospects for recovery. Although the mortality following such amputations must, therefore, be very much greater than that following primary or late amputations, cases will arise in which the very gravity of the local and general phenomena, such as recurrent hemorrhage, impending gangrene, or septicæmia, will necessitate the speedy removal of the limb, as the last hope of deliverance.

With the subsidence of the grave constitutional symptoms and the advent of profuse suppuration begins that period when, if amputations are performed, they are termed *secondary*. It has already been seen that the prospects for recovery after amputations in this period are less promising than after those of an earlier period. An equally strong objection to waiting for this period is that more of a limb must generally be sacrificed than by an early operation. Thus Guthrie observes that "When an amputation is delayed from any cause to the secondary period, a joint is most frequently lost: for instance, if a leg be shattered four inches below the knee, it can frequently be taken off on the field of battle and the joint saved. Three or four weeks after, the joint will in all probability be so much concerned in the disease that the operation must be performed in the thigh; the same in regard to the forearm and hand, and the upper part of the arm with the shoulder." Notwithstanding the drawbacks attending secondary amputations, certain circumstances frequently make them imperative. Continued fever, impending exhaustion from excessive and protracted suppuration, and evident uselessness of the limb, even if saved, may force the knife into the hand of the surgeon, after much valuable time has been lost through an error of judgment on his part, or a procrastination on the part of friends.

PREPARATIONS.—Before beginning an amputation it is essential to make such preparations for it as are required for every major operation. If possible, the amputation should be made in the early part of the day, in order that if there be much hemorrhage subsequent to the operation its source may be looked for without artificial illumination. It can be most satisfactorily performed on any operating table, or, in the absence of this, on two kitchen tables placed end to end. The instruments necessary for major amputations are: 1. An Esmarch elastic bandage and strap for the production of anæmia of the part to be removed. 2. A suitable tourniquet. 3. Amputating knives of various lengths and widths, with at least one double-edged blade (Fig. 118) (catling). 4. One large and one metacarpal amputating saw. 5. From six to twelve hæmostatic forceps. 6. A bone-cutting forceps, and a lion-jawed forceps. 7. Ligature and sewing materials, drainage tubes, needles, and an abundance of hot water.

FIG. 118.

The preparations which are to be made for the after-treatment, although they are necessarily a preliminary to the operation itself, will vary according to the plan to be adopted, and will be considered at some length hereafter.

While a finger or toe can be removed by a surgeon with only such aid as a layman can give, at least three assistants are required for every larger amputation. The duties of these should be first clearly defined by the operator, lest valuable time be lost during the operation. The undivided attention of one must be given to inducing and maintaining anæsthesia. The second is to support the part to be removed, after which he can be entrusted with the ligation of the vessels. The duty of the third should be confined to

controlling the circulation of the limb above the seat of operation, and eventually to retract the flaps. Where there is a fourth assistant, it should be his duty to hand the instruments to the operator as he may require them. This assistant is dispensable, since, when the instruments are placed on a table near the operator, the latter can help himself quite as expeditiously as when assisted to them. These details arranged, the patient is anæsthetized and brought into such a position that the limb to be removed is everywhere accessible. The part to be removed must now be carefully wrapped in towels, the entire limb thoroughly cleansed with soap and brush, and the hair removed from the part where the incision is to be made. The surgeon is then ready to take the final and most important preliminary measure for the amputation, that by which he intends to control the circulation of the limb and reduce the loss of blood to a minimum.

There are various methods by which the circulation may be more or less controlled during an amputation, and they are of sufficient importance to justify a detailed consideration. To prevent hemorrhage the surgeon can choose between tourniquets, digital compression, and the Esmarch elastic bandage, or combine the latter with one of the other two. From the time of Morel the ingenuity of surgeons has been taxed to devise an instrument which will safely compress the main artery of a limb above the point where an amputation is to be practised. Of the many instruments introduced, only a few have been able to gain general recognition. The oldest of these is the Spanish windlass or garrôt of Morel, which consists of nothing more than a wide band (g) of an unyielding material (muslin or linen), firmly drawn around the limb and tied. Over the main artery and at a point diametrically opposite, there are inserted underneath it compresses of linen, a piece either of thick leather or of paste board (p). At a point opposite the artery a firm rod (s, s) is introduced underneath the encircling band and is then turned in such a manner as to shorten the latter, and thus the compression of the main artery is effected (Fig. 119). Owing to the simplicity of its construction, the garrôt of Morel stands without a peer in cases of emergency in civil as well as military practice. It has, however, one very objectionable feature, which renders its use a matter of necessity rather than of choice. Notwithstanding the use of the pads of linen or leather already referred to, veins, arteries, and soft parts are compressed to an almost uniform degree; hence extensive venous hemorrhage and insufficient retraction of the muscles follow. A great improvement on the windlass is the tourniquet of Petit, which was in general use until the Esmarch strap was introduced. It consists of two metal plates, the distance between which can be regulated by a screw, and which are connected by a strong linen band supplied with a buckle, by which the limb is encircled (Fig. 120). To apply it properly, the limb should be surrounded by a few turns of a roller, while the body of the bandage (p) is placed over the artery (a). Over this bandage the lower metallic plate is then placed, and the band and buckle are fastened, when, by turning the screw, compression of the main vessel can be regulated at pleasure. The objection has been raised to the tourniquet of Petit that it compresses not only the artery, but also its accompanying vein, and thus induces venous stasis, and enhances the dangers of thrombosis. While this is doubtless true, it is an insurmountable

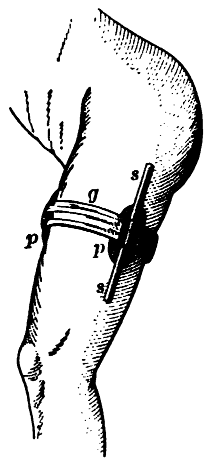

Fig. 119.—Morel's Tourniquet.

defect common to all tourniquets, and based more on theoretical than on clinical data. When properly applied the tourniquet of Petit is not apt to slip or yield, and its safety is such that in case of emergency the management of the screw might be entrusted even to a layman. In order to limit the compression to the main vessel alone, complete or incomplete metallic rings have been devised which, while they surround the limb more or less completely, make compression at only two points, *i.e.*, over the artery and at a point diametrically opposite. The best known tourniquets constructed on this principle are the horseshoe tourniquet of Signorini and Dupuytren, the arterial compressor of the late Professor Gross, and the abdominal tourniquet of Pancoast and Lister (Fig. 121). While with these the compression can be limited to the main vessels of the limb, and the circumferential constriction of the latter is thus avoided, they are more liable to slip than the tourniquet of Petit, and are far less reliable than digital compression. For certain amputations, however (of the hip and shoulder), the instrument of Petit is inapplicable; it is then that one or other of the horseshoe tourniquets or digital compression will be found indispensable.

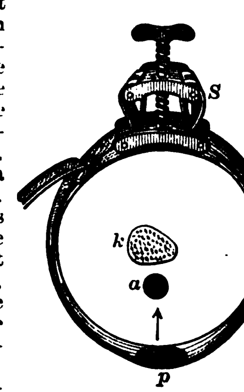

Fig. 120.—Petit's Tourniquet.

Digital compression, when made by trustworthy hands, is admirably suited to control temporarily the circulation. If compression of the artery alone is anatomically possible, it can be best accomplished by the finger. To be practicable, the vessel must be contiguous to a bone against which it can be pressed, as the femoral upon the os innominatum, the brachial upon the humerus, the subclavian against the first rib, or the abdominal aorta against the vertebræ. Since only a few minutes are required for the amputation of a limb, and the ligation of the larger arteries, the endurance of the assistant entrusted with the duty is not severely tasked. In digital compression, associated with the use of the elastic bandage, we have a combination with which the circulation of a limb can be completely controlled, and by which certain parts, the compression of which would be useless or even harmful, are protected. Notwithstanding the advantages of this method, the surgeon should never resort to it unless he can absolutely rely upon the ability and skill of his assistant. (For amputations at the hip or shoulder direct compression of the common iliac through a laparotomy wound, or of the subclavian through an incision above the clavicle is justifiable. With unreliable assistance temporary ligation of these vessels would be an absolute safeguard against excessive bleeding.)

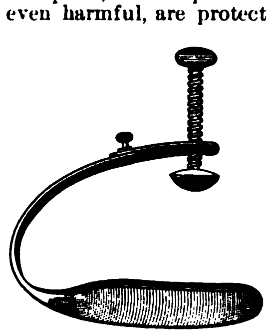

Fig. 121.—Horseshoe Tourniquet.

Elastic Compression.—Notwithstanding the precautions against hemorrhage after amputations, these were invariably associated with very great loss of blood until twenty years ago. The blood thus lost was venous in character, and came from the veins of the amputated member. Through the practices of Grandesso Silvestri, an Italian surgeon, and particularly of Esmarch, of Kiel, the blood contained in the part to be removed is saved, and that this is not an inconsiderable quantity has been demonstrated by experiment. The apparatus of Esmarch consists of an elastic bandage and an elastic tube or flat

band with chain or clasp attachments. Commencing at the fingers or toes, the bandage is applied by spiral turns until the limb is covered to a line at least four inches above the point where the bone is to be divided. Above the last turn of the bandage, the elastic band or tube is rather firmly and repeatedly wound around the limb, and secured by clasp or hook and chain (Fig. 122). When the bandage is then removed, a condition of ischæmia is observed in the limb, which will permit its amputation without a more than appreciable loss of blood during the operation proper. In recent years the elastic bandage has been abandoned because of the danger of disseminating the infective or malignant process for which the amputation is to be done. By elevating the limb for five minutes before applying the strap, complete ischæmia can always be induced. When the elastic strap is removed, the integument of the stump rapidly assumes a bright-red color, and in the wound there appears free, persistent, and often embarrassing, capillary oozing. It is generally accepted now that the source of this hemorrhage is from the dilated capillaries, the walls of which have been paralyzed in consequence of the pressure exerted by the strap on the vasomotor nerves. When in from twenty to thirty minutes the vessel walls regain their tonicity, the hemorrhage ceases. To check this capillary oozing, a number of remedies have been suggested. That of Riedinger, to apply the faradic current, while very serviceable, is not always practicable. Esmarch relies upon closure of the wound and elevation of the stump before the strap is entirely removed. Hot water (150° to 180° F.), applied with sponges, often acts admirably in these cases. Since compression of the vasomotor nerves, caused by the bandage, is the cause of this parenchymatous hemorrhage, this can best be obviated by completely substituting digital compression for the elastic strap, or, if the latter be used, by preventing the ingress of blood by the use of a tourniquet until the vessels have regained their natural tone. The latter plan, as practised by Ashhurst, is "to place a tourniquet in position, but not screwed down over the main artery of the limb, and then to apply the Esmarch tube a few inches above the point at which it is intended to amputate. As soon as the principal vessels have been secured, the tourniquet plate is screwed down and the tube removed. No bleeding follows, and by the time that the remaining arteries requiring ligatures have been tied, the vessels will have regained their tone, and the tourniquet can be removed without any risk of bleeding following." In amputations near the trunk, the elastic strap or tube should not be used in the ordinary manner (see Special Amputations). In an amputation of the shoulder, and in another of the hip, I have seen it loosen or slip over the stump immediately after the disarticulation was effected, and in both instances the hemorrhage was most alarming. In amputation at the shoulder, when, by the use of the bandage, the blood in the extremity has been returned to the economy, it is better to rely upon compression of the main artery against the first rib with the finger or a padded key. In amputations of the hip, the main artery can be compressed against the pubic bone, or even the circulation in the aorta can be controlled by one of the many compressors already referred to.

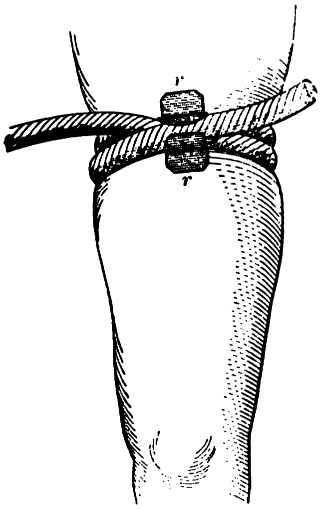

FIG. 122.—Esmarch's Apparatus. (Bandage not shown in cut.)

METHODS OF AMPUTATION.—Every amputation consists of three steps: (1) Division of the soft parts; (2) division of the bone, or disarticulation; (3) ligation of the vessels and closure of the wound.

According to the method adopted for the division of the soft parts, amputations are classified as circular or flap operations, and in the choice of the method the surgeon must be guided by the condition of the soft parts about the bone, the ease with which the joint can be opened in a disarticulation, the probable position of the cicatrix and form of the stump, and, above all, the desire to save as much of the limb as possible. Of the circular and flap operations, all methods of amputation may be said to be but modifications. By the circular method it is attempted to give to the stump the form of an inverted cone or funnel, the apex of which is occupied by the divided end of the bone, the base or margin of which is represented by the cutaneous margin of the wound. In the flap operation the soft parts are so divided as to make one or more flaps, the bases of which are on a level with the divided bone, and the free margins of which are so adapted to each other as completely to cover the bone and admit of the ready closure of the wound. Whatever plan of operation is adopted, the surgeon should stand in such a position that he grasps the stump with his left hand, and that the amputated part therefore falls toward his right side.

Circular Method.—All modifications of the circular method call for a similar incision through the skin and subcutaneous cellular layer, this incision being made around the entire circumference of the limb and at a right angle to its axis. According to the depth to which the incision is carried, the method is subdivided into that by single incision and that by double incision.

Single incision: This, as already remarked (see History), is the oldest method of amputaticn, and is generally known as the Celsian operation. After retraction of the soft parts, a long amputating knife is swept around the limb, and all of the soft parts are divided down to the bone. This is then divided on a slightly higher level by the retraction of the soft parts. While this operation yields the smallest wound, and is the most rapid in its execution, its manifest disadvantage is in the insufficient covering which it affords for the bone. It is admissible only in greatly emaciated subjects. Brünninghausen, in the beginning of the century, reintro-

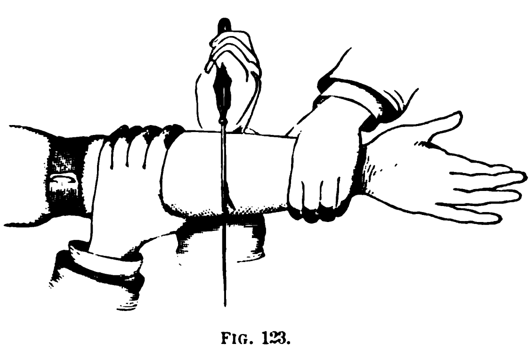
FIG. 123.

duced this method, but, after the amputation of the limb was completed, made a second section of the bone several inches above the point at which it was first divided.

Double incision: This operation, of which those of Petit, Cheselden, B. Bell, Desault, and Alanson are but unimportant modifications, has received its name from the fact that the skin, underlying fascia, and muscles are divided upon different levels, and, therefore, by at least two circular incisions. It is made as follows: The surgeon, firmly holding the limb with the left hand, carries his right hand, in which he firmly holds a large amputating knife, underneath and around the limb until

the heel of the cutting edge is over the uppermost part of the line of the proposed incision. Giving the knife this position forces the operator into a more or less stooping posture, from which he raises himself as the incision is completed. This is commenced with the heel of the knife, which, by a single sweep, is carried around the entire circumference of the limb, severing the skin and adipose layer down to the deep fascia (Fig. 123). Two incisions, the ends of which meet, will answer as well as the division by a single sweep of the knife. As soon as the integument is divided the wound gapes. The upper margin is raised by the thumb and finger of

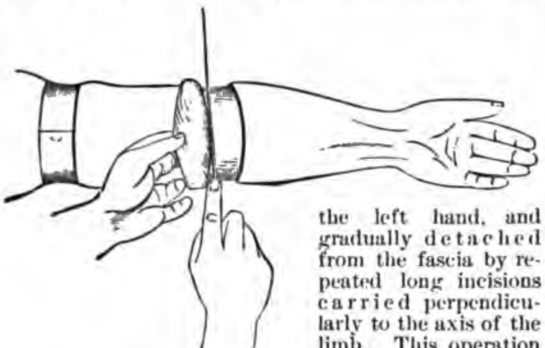

FIG. 124.

the left hand, and gradually detached from the fascia by repeated long incisions carried perpendicularly to the axis of the limb. This operation of detachment is continued until the skin and adipose layer can be reflected like a cuff, the length of which should be equal to half the diameter of the limb (Fig. 124). Where the latter rapidly increases in circumference, or there is a thick subcutaneous layer, or this has been infiltrated, the reflection of a cuff is often impracticable. Then two longitudinal incisions, diametrically opposite each other, will materially facilitate this part of the operation, al-

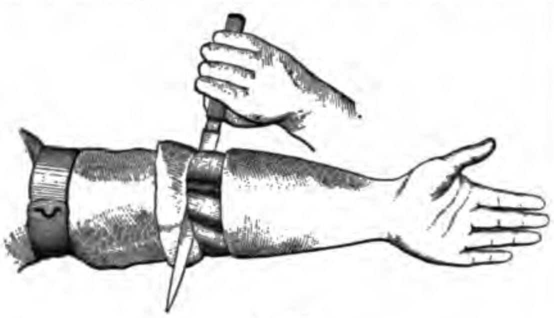

FIG. 125.

though by this means the amputation is in a manner converted into a flap operation. The integument having been reflected to the required extent, the muscles are next divided close to the line of reflection by one steady circular sweep of the knife, which should cut through everything down to the bone (Fig. 125).

Where there is but one bone to be divided, the surgeon is now prepared to use the saw. Where there are two bones, the interosseous tissues remain to be divided. Whereas this can be accomplished with an ordinary amputating knife, it is safer to use a double-edged instrument (catling) for this purpose. By using it in the manner indicated in Fig. 126, there is no danger of cutting the blood-vessels twice, and thus one danger of troublesome hemorrhage is avoided. To protect the soft parts from injury by the saw, they must be well retracted by the hands of an assistant, or by the use of a band of muslin (retractor) divided into two or three slips, according to the absence or presence of an interosseous space (Fig. 127).

When it is deemed advisable to save sufficient periosteum to cover the divided end of the bone, this can now be readily effected with the back of the knife or the handle of the scalpel. The utility of this procedure must certainly be questioned, since in a number of instances it has interfered with the ready drainage of the medullary cavity, and has thus been the indirect cause of a fatal issue.

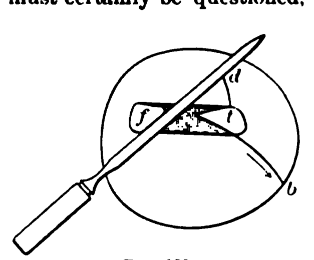

FIG. 126.

The movements of the saw can be greatly facilitated by guiding them with the nail of the left thumb (Fig. 128). The to-and-fro movements of the saw should be slow, lest the heat developed by its too rapid use endanger the vitality of the bone. Where there are two bones of the same diameter (forearm), they should be divided simultaneously. In the leg, the tibia is to be almost entirely divided before the section of the fibula is commenced. Unless this precaution is adopted, splintering of the bone is not easily avoided. For the same reason, the assistant in charge of the part to be amputated should hold it horizontally, allowing it neither to drag by its weight nor to be raised in a manner to interfere with the movements of the saw. Should splintering of the bone nevertheless occur, the splinters and sharp margin of the latter must be removed with the cutting bone forceps.

Oval Method.—Holding an intermediate position between the circular and flap operations is the oval method, which, although practised by the older Langenbeck and others, was first generalized by Scoutetten (1827). The essential feature of this amputation in the continuity of the limb is, that the incision, instead of

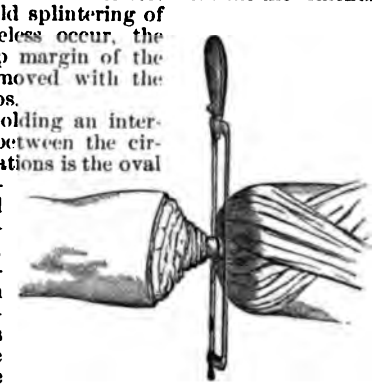

FIG. 127.

being made perpendicular to its long axis, is carried at an angle of forty-five degrees, and in such a way that the soft parts in front of the bone are divided upon a higher level than those on its posterior aspect. At the same time the upper portion of the wound is converted into an acute angle, whereas its lower portion is given an oval outline. The upper extremity of the wound is placed at the point where the bone is to be divided. The operation is commenced by two incisions, in the form of an inverted V, the lower ends of which are united by a transverse cut on the posterior surface of the limb (Blasius). Here, as in the circular amputa-

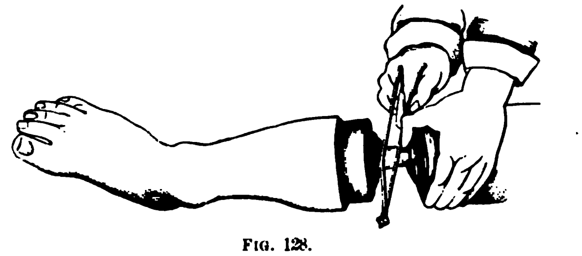

FIG. 128.

tion, by a single incision all the soft parts are divided at once on each side of the bone, and then those on its posterior aspect. This operation has been generally discarded for amputations in the continuity, although for

disarticulations at certain joints it presents advantages which are worthy of consideration (see Fig. 129).

Flap Method.—As already indicated, this consists in the formation of one or more flaps, comprising integument and muscular tissue, or integument alone, and designed in a manner completely to cover the divided extremity of the bone or its exposed articular surface. According to the anatomical components of the flaps, they can therefore be called tegumentary and musculo-tegumentary.

FIG. 129.

Tegumentary Flaps.—This operation is generally practised by making two semilunar incisions, the ends of which meet on opposite sides of the part, down to the deep fascia, and dissecting up the skin and subcutaneous cellular layer to an extent sufficient to cover the stump (Fig. 130). When it is practicable, the flap should be taken from the anterior and posterior aspects of the limb in the forearm, thigh, and leg, and they should not be of equal lengths, the anterior flap usually being made longer, to fall like a curtain over the divided end of the bone, where it comes in contact with the posterior (shorter) flap. In recent years the tegumentary method, with only one cutaneous flap, made from the anterior surface of the limb, has been most highly advocated (Carden, Bruns). When, from choice or necessity, a single tegumentary flap is to be made, the incision should be commenced on a level with the point where the division of the bone is contemplated, and carried for a varying distance down one aspect of the limb, parallel to its axis, and then by a wide curve on the opposite side to a point on a level with its commencement (see Fig. 130). In this manner the base of the cutaneous flap extends over half the circumference of the limb, while its length should be greater than its antero-posterior diameter at the level of the amputation. After separation of this flap from the deep fascia (it may be made to include this) it is reflected and the ends of the incision are united by a posterior incision carried perpendicularly to the axis of the limb as in the circular operation (Fig. 131).

FIG. 130.

Whether one or more cutaneous flaps be made, the division of the remaining soft parts is practised by a single sweep of the knife, carried perpendicularly around the limb at the base of the flap, as in the circular operation. Owing to this division of the muscles, amputations by the tegumentary flap method are not infrequently called "modified circular operations."

Musculo-tegumentary Flaps.—Here, as in the tegumentary method, one or more flaps may be made, to cover the stump. They may be formed by transfixion

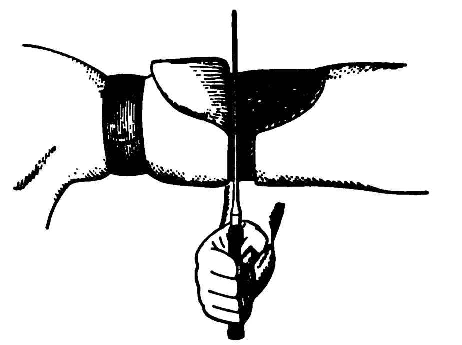

FIG. 131.

of the limb and cutting from within outward, or by cutting from without inward, or by making one flap by the former and the other by the latter mentioned method. Where there is but a single bone (thigh, arm), it is customary to make at least one flap by transfixion. The integument being well retracted, and the soft parts raised from the bone with the left hand, a sharp-pointed and large amputating knife is passed through the limb from side to side, the knife being made to graze the surface of the bone (Fig. 132). By a sawing movement the instrument is gradually carried downward and forward, and then obliquely outward, thus forming a wide

FIG. 132.

flap with convex margin. The danger of making a flap too narrow is best avoided by not cutting outward too soon. The knife is then entered at the angle of the wound on one side, passed around the bone on the side where the soft parts are still adherent, and out at the opposite end of the wound. The second flap is then made by cutting outward as before. The flaps being now retracted, the knife is rapidly carried around the bone, as high as possible, to divide the muscular tissue still adhering to it. The application of the saw then follows. In order to make sufficient allowance for shrinkage, the flaps should have a length at least equal to three-fourths the diameter of the limb. Redundance of the flap is always preferable to insufficiency, since the excess of muscular tissue can easily be removed with a few strokes of the knife. In flap operations, owing to unequal retraction of the soft parts, tendons and nerves are particularly apt to protrude above the surface of the wound, thus giving it an irregular appearance, and interfering with its ready union. After ligation of the

blood-vessels, these protruding masses are to be carefully removed with the scissors. The protrusion of the muscular tissue of the flap and the irregularity of the latter can be totally avoided by cutting from without inward. This plan, generally known as that of Langenbeck (Fig. 133), insures perfect symmetry of the flaps, and permits the ligation of the vessels as they are exposed or divided. It is also practicable to cut through the skin and subcutaneous tissue from without inward, and complete the operation by transfixion. Although already practised by Dupuytren, this plan has been recently advocated by Agnew ("System of Surgery," vol. ii., p. 305).

Rectangular Flap.—In 1855 Mr. Teale, of Leeds, practised the

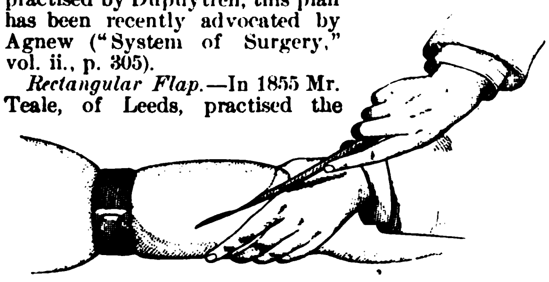

FIG. 133.

formation of one long and one short rectangular flap, each of which comprised one-half the circumference of the limb and all the tissues down to the bone. The operation is made as follows: A rectangular anterior flap (posterior in the forearm), equal in length and breadth to half the circumference of the limb at the base of the flap, is marked out by one transverse and two parallel longitudinal incisions, the latter involving only the skin and superficial fascia, and the former being carried down to the bone. The longitudinal incisions should be so placed that the posterior obtains one-fourth the length of the anterior flap. The two flaps are then turned up from the bone from below upward, and the saw is applied. To insure equal width of the flaps at their bases and their extremities it is best to map out the flaps by actual measurement before the incisions are made. In closing the wound, the long flap is doubled upon itself so that the square ends of the two flaps are brought into apposition, where they are retained by a number of sutures (Fig. 134)

COMPARISON OF METHODS.—The surgeon who would obtain the best results after amputations should be familiar with all the different methods without becoming too partial to any, since the condition of the part to be amputated, the thickness and vitality of the subcutaneous cellular tissue, the position of the wound, and many other circumstances should guide him in the selection of a method rather than individual preference. To save as much of a limb as possible must be the first aim of the operator, and this can be accomplished only by resorting to various methods according to the exigencies of individual cases. If one method of operating deserves a preference, it is that by tegumentary flaps with circular division of the remaining soft parts. By this method the position of the angles of the wound for favorable drainage and that of the cicatrix can be readily determined, and when two oval cutaneous flaps are made no anxiety for their vitality need ordinarily be entertained. When the subcutaneous cellular layer is very thin, there is a manifest advantage in dissecting up with the integument some of the superficial muscular fibres. The marked advantage of the tegumentary flap over the circular method lies in the fact that by it, when the disease extends higher on one side of the limb than on the other, it often enables us to amputate several inches lower than we could by the circular method. While during the early part of this century the musculo-cutaneous method, by transfixion, was very extensively practised, on account of the rapidity with which it could be executed and the muscularity of the stump which it left, it is gradually being discarded for two reasons chiefly. In the first place, the general use of anæsthetics has removed the necessity for unusual haste, and in the second place, the muscular tissue left in the stump generally undergoes atrophic changes from disuse during the first year. A most decided disadvantage of the musculo-tegumentary flaps exists in the oblique division of the blood-vessels, on account of which they are often difficult to find and to ligate. It is for this reason that secondary hemorrhages are more prone to follow amputations made by this method, although by proper care in the act of ligation and with sufficient compression of the stump with the dressing this can usually be avoided. The circular operation commends itself, owing to the facility with which it can be executed, even by a novice in the operative art, and by its special applicability for amputations in certain parts, as in the forearm and lower part of the leg. Where the operator can choose his method, amputations may be made with good results as follows: In the arm and forearm, by circular method or rectangular flaps; in the upper part of the leg, by tegumentary and rectangular flaps (lateral or antero-posterior); in the lower part of the thigh, by antero-posterior muscular flaps; in the middle of the thigh, by one tegumentary flap raised from the anterior surface of the limb. The oval method will be found particularly applicable to amputations at certain articulations, while the method of Teale, which has not been extensively practised in this country, will give good results in amputations of the leg and forearm where the injury or disease has invaded a limb more extensively on one side than on the other.

LIGATION OF VESSELS.—When the amputation proper is completed, the entire attention of the operator must at once be directed toward permanently controlling the hemorrhage. For this purpose it is best to grasp the divided blood-vessels, one after another, as they are seen, with hæmostatic forceps, which are allowed to remain in the wound until all the vessels are thus held. This accomplished, the vessels are separately tied with (animal ligature or carbolized) catgut or silk. The ligatures are then cut short. Veins should be tied to avert the development of a general infection out of a possible local infection. As a rule, not more than from four to six arteries will require ligation in all amputations, except those of the hip and shoulder, although long-standing disease (large neoplasms or pre-existing occlusion of the main artery) may have multiplied the number of vessels requiring ligation. Here, as in ordinary wounds, at least the larger arteries should be carefully exposed before the ligature is applied. In the smaller vessels, where their exposure would entail an unnecessary loss of time, portions of the tissues in which

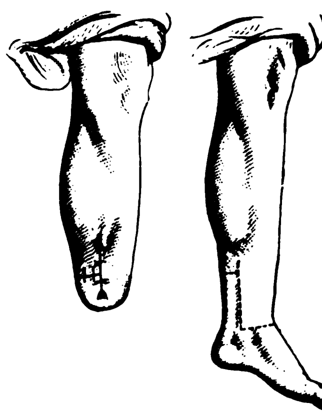

FIG. 134.

they are embedded may safely be included in the ligature by passing this with a needle behind the bleeding vessel. The question has for a long time been discussed as to whether the veins should be ligated. There can be no question but that the ligature of the divided veins removes a common source of secondary hemorrhage, and materially reduces that immediately following the removal of the Esmarch bandage. The opposition to the ligation of veins in amputations has been mainly based upon the fear of exciting an ascending phlebitis and of giving rise to embolic processes. That these fears are utterly groundless has been conclusively demonstrated. "Of forty cases of ligation of the internal jugular vein, death was fairly ascribable

to the ligature in only four, all due to secondary hemorrhage coming on about the time of the separation of the thread. In not a single instance was diffused phlebitis excited. In twenty cases of ligation of the external jugular vein, and fifteen of the axillary, additional evidence of the safety of ligation of veins is recorded." The most troublesome hemorrhage is the parenchymatous oozing which supervenes when the Esmarch bandage is removed. How to contend against this has already been discussed (see above). It is proper to add, however, that in every case the application of an abundance of hot water is of unquestionable value. When the oozing from the divided end of the bone is not checked by this, the medullary canal may be temporarily plugged with clean white wax, or with sterile gauze. The accurate closure of the wound and pressure upon it by a well-applied bandage are among the best means of checking the capillary hemorrhage. When it is necessary to resort to this means, a large gauze pad is firmly pressed against the wound and retained until the sutures are passed. As the sutures are tightened the pad is gradually withdrawn while an assistant tightly presses the wound surfaces against each other. In large amputation wounds, the size can be greatly reduced by buried continuous catgut sutures which bring the divided muscles close together. Sutures thus applied in purse-string fashion or in tiers help to cover the bone and to prevent the formation of dead intermuscular spaces.

After-Treatment.—It is beyond the scope of this article to enter into an extended discussion of the various methods of treatment of wounds, although in hardly any other class of wounds are the good or evil results so clearly attributable to the manner of treatment adopted. The question at once presents itself whether the surgeon will pursue a course which will reasonably assure a total, or at least partial primary agglutination of the wound, or whether he will avoid the dangers of retention and decomposition of the secretion of the wound by treating this openly, thus expecting its closure by the slower process of granulation. The latter plan, which is now known as the "open method," was first enunciated by Vezin, Bartscher, and Burow, in Germany (*Deutsche Klinik*, 1856), and disseminated in this country by the late Dr. James R. Wood. When this method of treatment is adopted, sutures, adhesive straps, etc., are entirely dispensed with, the stump being comfortably placed on a pillow or pad, and the wound freely exposed to the air. A mass of absorbent cotton is placed underneath the stump to catch the discharges from it. Twice daily the wound is irrigated with an antiseptic solution, usually of carbolic acid, until at the termination of the first week, when the process of granulation has been thoroughly established, the edges of the wound are approximated by adhesive strips, care being taken that retention does not occur. The manifest advantage of the "open method" of treating amputation wounds is in the ready outlet which is given to the secretions. Their decomposition in the wound is thoroughly prevented, and the chief factor of septic absorption is thus avoided. However admirable the results which have been obtained from it, the length of time required for the closure of the wound (six to twelve weeks) militates against its general adoption. While incomparably better than the older methods of tightly closing the wound regardless of proper drainage, the open treatment of wounds has subserved its purpose, and has yielded to the superior advantages of the aseptic method, which strives to obtain the ideal of the surgeon in the treatment of wounds, viz., primary union. The open treatment of amputation wounds has been therefore properly relegated to those cases in which the surgeon is convinced that, from the condition of the parts in which the operation has been made, or from the general condition of the patient, primary union cannot take place.

When a doubt exists as to the certainty of primary union, sutures should be passed both deeply and superficially and left untied. The wound itself is packed lightly with sterile gauze. If, at the end of forty-eight or seventy-two hours, there is no evidence of septic infection, the gauze may be removed and the sutures closed with prospect of securing union without suppuration. When, on the other hand, primary union is aimed for, all drainage is to be dispensed with unless there is considerable oozing. The rubber drainage tube formerly extensively used is gradually being replaced by a narrow wick of sterile gauze drain passed through the angle of the wound from the immediate vicinity of the divided bone. This can be removed on the third or fourth day, or, if there is no evidence of infection, may be allowed to remain until the first dressing is changed, after a week or ten days. When, as in the case of amputation of the heel (Syme), there is danger of the formation of a dead space, one of the flaps can be perforated in such a manner as to prevent pocketing of wound secretion. Although an advocate of limiting drainage as far as possible, the writer believes it should be resorted to in every case in which oozing has not been entirely stopped by the time the sutures are ready to be tied. Primary union is often prevented by the accumulation of bloody serum, which mechanically separates surfaces which ought to be held in apposition.

An amputation wound is to be closed by three or four deep sutures, which should include the entire thickness of the muscles on each side of the divided bone. They should be of silver wire or silkworm gut. The superficial sutures should be placed at distances of about one-third of an inch from one another. In recent years the writer has formed the habit of bringing the divided muscles together by tiers of buried catgut sutures, and the wound margins by subcuticular silkworm-gut sutures.

The dressing of the wound follows. The amount of material used should be ample and it should be so applied that pressure will tend to keep the wound surfaces in apposition. Unless a moist dressing is deemed advisable because a doubt as to the asepsis exists, a dry dressing should always be used with scrupulous attention to surgical cleanliness. Even large amputation wounds, as those of the thigh, hip, or shoulder, will generally heal under one or two dressings. As in other operations, the dressing should be allowed to remain for at least a week or ten days. Should there be a slight oozing, a change of dressing is imperative. The stump should always be maintained in an easy position on a pillow or on a well-padded posterior splint. It is usually advisable to elevate this to a degree sufficient to facilitate the return of blood through the veins. Post-operative oozing can thereby be best prevented.

After amputations in which the asepsis has been successfully carried out, even the largest wounds will heal entirely by first intention. The dissimilarity of tissues which are often brought in contact with one another in an amputation wound, and which were formerly supposed to preclude the possibility of immediate union, is no obstacle to the achievement of this result. Of greater importance are the novel relations of the blood-vessels to one another. The circulation of the veins of the stump has lost the *vis a tergo* so essential to the proper performance of their function, while the smaller arteries are distended with blood in consequence of the interrupted circulation in the main vessel. It is for this reason that a marked œdema and congestion will often manifest themselves in the stump. Unless infection has occurred, these manifestations will disappear in three or four days.

In whatever manner the wound heals, certain marked changes will occur in the stump. The muscular tissue undergoes atrophic changes, its fibrous elements becoming firmly adherent to the end of the bone. This itself gradually decreases in size, the end becoming rounded off and often covered by a rounded osteophyte formed from the periosteum or from the granulations springing from the medullary canal. Where two bones are present, an irregular osseous bridge not infrequently unites them (see Gueterbock, *P. Arch. f. klin. Chir.*, Bd. xv. and xvii.). As a rule, the end of the bone is intimately united to the soft parts covering it, although at times a

bursa is developed between them. The ligated vessels are converted into firm fibrous cords for a varying distance, and are reduced in size, not only in the stump but also in the entire limb. Thus, in amputations of the leg, the artery and vein are reduced over one-half in size, as high as the inferior vena cava and the bifurcation of the aorta. The divided nerves lose their nervous elements by atrophy, while their connective-tissue components increase in number until their extremities are often expanded and bulbous, thus forming false neuromata.

COMPLICATIONS.—Pain and muscular spasm may be said to be present to a greater or less degree after every major amputation. They usually supervene soon after the patient regains consciousness, and may develop to a distressing severity, particularly in persons of a nervous and irritable disposition. For the relief of these symptoms hypodermatic injections of morphine act most promptly. The jactitations of the stump are most successfully overcome by lightly fastening the stump with a few turns of a bandage to a well-padded posterior splint.

A very slight reaction may be said to be necessary to the process of repair. When infection has taken place, the evidences are speedily seen in the wound. It may lead to more or less extensive suppuration, to a limited sloughing, or to gangrene of the stump. When such severe inflammation attacks the wound, the stump becomes exquisitely sensitive and hot, and assumes a dusky red and glistening appearance. The discharges from the wound are scant and offensive, while the elevated temperature and hard and rapid pulse sufficiently indicate the constitutional disturbance. When the inflammatory process extends along the intermuscular spaces the limb becomes sensitive to the touch, and swollen for a considerable distance above the seat of operation. When suppuration ensues all may yet be well. On the other hand, the exudation into the tissues may develop in proportions incompatible with the vitality of the parts, when extensive sloughing, and even gangrene of the entire stump, may result.

The treatment of these conditions must be conducted upon established antiphlogistic principles; iron, quinine, salicylates, and alcoholic stimulants are almost always indicated. For the local condition nothing answers so excellent a purpose as measures which relieve the tension. Stitches, when too tight, must be removed, and as soon as a suspicion of purulent accumulation is aroused, free incisions are to be made. When such extensive suppuration has supervened it is advisable to remove all constricting dressing, and to treat the wound by the open method, removing sloughs as fast as they are formed. Frequent irrigations with sublimate solutions and hydrogen dioxide are now indicated. As a dressing the balsam of Peru (ten per cent.) in castor oil applied on strips of gauze will do away with the necessity of drainage. As an especially dangerous seat of inflammation the medullary canal of the bone must be referred to. Periostitis and osteomyelitis are particularly prone to follow amputations made for gunshot injuries. It usually manifests itself during the first week after the operation by a brownish or greenish appearance of the medulla, the bone appearing dull and devitalized, while the periosteum is detached from its surface. The pain is usually very severe, and associated with it are the well-known symptoms of systemic infection, *i.e.*, rigors, elevated and irregular temperatures, diminished secretion of the kidneys, and a dry and thickly coated tongue. Not only does this condition lead to extensive necrosis when recovery ensues, but frequently death results from the absorption of the pus which is retained in the medullary canal. The only measures that offer any hope for this condition are to scoop out the bone cavity with a sharp spoon, and if this prove unavailing, to resort to a second amputation at the nearest joint. However desperate this procedure may be, a very large number of cases have been reported in which lives have been saved which, without it, would have been inevitably lost.

As a sequel of moderate inflammation of bone, necrosis of its extremity is not infrequently encountered. This may result from devitalizing of the bone from excessive heat generated by the improper use of the saw. If the necrosis be limited to the divided end, this condition does not interfere with the primary union of the greater part of the wound. The existence of such a superficial sequestrum can be deemed probable when, after the permanent closure of the wound, a fistulous tract continues to discharge more or less pus. Its actual presence can always be recognized by the cautious use of a probe. When the sequestrum is of larger proportions, numerous fistulous openings will usually be found in the soft parts, which are then more or less adherent everywhere to the bone. The treatment of this condition must be palliative until nature has completely separated the sequestrum, when it can ordinarily be removed with little difficulty by laying the fistulæ freely open. When the sequestrum is large, it occasionally becomes necessary to resort to a formal sequestrotomy for its removal. In a very small proportion of cases the irritation consequent upon the long-standing discharges from the necrosis of the bone gives rise to epithelioma of the latter, for the relief of which a second amputation is usually necessary.

One of the most dreaded complications of an amputation is hemorrhage. It may supervene within a few hours after the completion of the dressing, or as late as the third or fourth week. The sources of early and late hemorrhages after amputations differ materially. The former arise from small arteries or veins that have escaped ligation, from arteries divided above the ligature, or from the divided capillaries of the muscles. This condition is readily recognized by the staining of the dressing, the distended appearance of the stump, and the flowing of blood from a number of places where the edges of the wound have been separated. The rapid distention of the stump and the bright hue of the blood which is discharged, at once indicate the arterial source of the hemorrhage. The darker appearance of the blood and its appearance in a sluggish stream sufficiently indicate its venous origin. When the hemorrhage is slight, and particularly if it can be recognized as venous, elevation of the limb and the application of ice may suffice for its control. When it becomes evident that such simple measures are futile, the wound must be reopened, the coagula removed, and the bleeding vessel found and ligated. When it is found that the hemorrhage has come from the medullary canal, this must be treated in the manner already described. The hemorrhages which supervene during the second week, or even later, usually result from the softening of the plug that occluded a ligated vessel, or from erosion of the latter from primary disease of the vessel wall, or from its being bathed in pus. By cutting short both ends of the ligature the necessity for the "cutting through" of the latter is done away with, and at least one important factor in the causation of late hemorrhages is thus removed. For the relief of late hemorrhages, compression of the artery by a compress and firm bandage should first be tried. When this proves unsuccessful, pressure should be made at different points of the main artery to determine the point nearest the stump where the hemorrhage can be controlled. Here the artery is to be exposed and ligated, or, what seems to be preferred by most recent writers, it may be included in the pressure of an acupressure needle. In extreme cases it may become necessary to resort to reamputation.

A peculiar and very rare condition of the stump is the development in it of a dilatation of the blood-vessels, commonly in the form of an aneurismal varix. Cases of this nature have been recorded by Cadge, of Norwich, England, by Gross, and by Agnew. Whereas, in some cases of this kind, operative treatment would not be called for, in others it may become directly indicated. Thus, in the case of Gross ("System of Surgery," vol. i., p. 530), ligation of the femoral was deemed necessary. The operation resulted fatally, from secondary hemorrhage, on the sixth day.

The form of the stump very frequently gives rise to

considerable annoyance and suffering. A healthy stump should present a nicely rounded outline, with the bones hidden beneath and away from the cicatrix. From a variety of causes this normal appearance of the stump may give place to prominence of the bone, retraction and ulceration of the soft parts covering it, and uselessness of the part for locomotion. Such an abnormal condition is commonly known as the "conical" or "sugar-loaf" stump. It may result from an insufficiency of flap, from inordinate retraction of the soft parts, or from gangrene of the integument alone. It is a condition which is more likely to follow the circular and tegumentary flap amputations, although with ordinary precautions it would seem that amputations in healthy tissues should not result in a badly formed stump. When this condition does result, nevertheless, its treatment must vary according to the extent of the deformity. When from an insufficiency of flap or excessive retraction of the soft parts, the end of the bone assumes a too prominent position, the flaps can be drawn down by appropriate bandaging, from above downward; or, by the aid of adhesive straps and weights, extension may be made in such a way as to cover the end of the prominent bone with

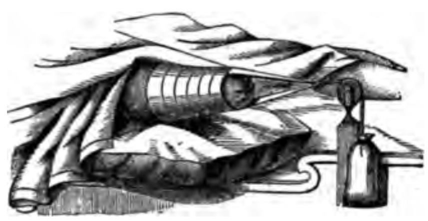

FIG. 135.

integument (Fig. 135). When, notwithstanding these measures, the proper relation between bone and soft parts cannot be brought about, nothing remains but to enlarge the wound, remove the periosteum from the bone, and divide this several inches above the level of the first section. It is unnecessary to defer this until the first wound has cicatrized. In extreme cases of conical stump reamputation will be indicated. It can be more highly recommended since reamputation is not often followed by bad results. Mr. Bryant refers to a very interesting condition of amputation stumps in children, in whom the development of conical stumps may be in a measure expected, since, in the process of growth, the bone appears to develop more rapidly. In the case of a boy whose leg was amputated, he found it necessary on two occasions, at intervals of three years, to remove two pieces of bone at least an inch long.

Neuroses of the stump are among the most intractable of its diseases. They may appear in the form of severe neuralgias, or in the form of spasmodic muscular contractions. The former condition usually depends upon an adherence of the divided nerves to the bone or the cicatrix, while in exceptional cases it results from the bulbous enlargement of the extremities of the nerve. For the relief of the former condition, subcutaneous division of the adherent cicatrix must be practised. Where neuromata can be felt, these are to be removed; when, from the number of these enlargements or from their deep positions, this procedure is impracticable, nothing short of a reamputation will give relief. Continuous jactitations, or "chorea" of the stump, as it might be termed (Gross), is very rarely encountered. It is more prone to develop in the thigh than elsewhere. The stump, when thus affected, is the seat of a constant tremor, often sufficiently active to be noticed when the limb is covered. In a case of this character which I saw two years ago, and which involved the thigh in an otherwise healthy subject, the spasms continued, notwithstanding all efforts to allay them. The most efficient measure was the deep injection of ether, which would relieve the spasm for about two weeks at a time, when the injection had to be repeated.

PROGNOSIS AND MORTALITY.—In estimating the inherent dangers of the operation, we must take into consideration only those cases in which the individuals operated on were—aside from the lesion which necessitated the operation—in the enjoyment of comparatively good health. As it is incorrect to attribute the immense mortality of tracheotomy for diphtheritic croup to an operation which, if performed for the removal of foreign bodies, is almost always successful, so it is manifestly improper to attribute most deaths after amputation to the operation itself. A compilation of the amputations of "expediency," made in Guy's Hospital, indicates a mortality of 26.8 per cent. If we remember, however, that these statistics of Bryant and Golding Bird include amputations made for neoplasms, and that the most valuable methods of after-treatment were at that time not employed in the hospital in question, this percentage must be misleading as to the inherent dangers of amputations. That the mortality of the operation under favorable circumstances can be greatly reduced from the percentage above given can be easily demonstrated. Thus, of 716 late and pathological amputations collected by Sir James Y. Simpson from smaller hospitals and private practitioners of Scotland and England, only 74, or 9 per cent., died. Of 100 amputations (including 39 of the thigh) made by Bruns, only 12 terminated fatally. According to the latest statistics of Bruns, of 204 major amputations 2 per cent. only died. Finally, of 187 amputations made by Volkmann for disease, only 7 succumbed (3 per cent.). This number includes 74 amputations of the thigh with only 2 deaths.

Unhappily these statistics are largely at variance with those gathered either from large hospitals or from the battlefield. Thus, of 560 larger amputations for all causes collected by Malgaigne in the hospitals of Paris, 299 ended fatally, the mortality being 53 per cent. The fatality attending amputations by English surgeons in the Crimean campaign is represented by 426 operations, with 169 deaths (39.6 per cent.), while the figures of the French surgeons during that war are 4,390 amputations, with 3,218 deaths, giving the appalling mortality of 73 per cent. Compared with such results those obtained during the War of the Rebellion show a most decided improvement. Of 29,980 amputations, the result was determined in 28,261; of these, 20,802 recovered. There were 7,459 deaths, thus yielding a mortality of 26.3 per cent. This is about the fatality that attends amputations in civil practice in the larger hospitals of this country and of England, although occasionally better results are recorded. Thus, of 100 amputations made in the Pennsylvania Hospital (1874–78) only 17 died, while of 539 amputations made for all causes in St. Bartholomew's Hospital (1873–82) only 88 died, giving a mortality of 16.3 per cent.

John F. Erdman,* in 1895, tabulated the statistics of amputation performed in the leading hospitals in New York, done during the decade preceding. Of 709 major amputations 109, or 15 per cent., died. Page† in 1895 collected 712 major amputations from the infirmary, Newcastle-upon-Tyne, of which 61 died, giving a mortality of 8.5 per cent. In 30 of the fatal cases death resulted from shock and loss of blood. Forty years before, Fenwick had tabulated 225 amputations done in the same infirmary with a mortality of 54, or 24 per cent. Of 163 amputations done in the Cincinnati Hospital during the decade preceding January 1, 1900, 19 terminated fatally. The gross mortality of the series was 12.7 per cent. From the clinic of Bruns‡ comes the remarkable record of 81 amputations of the leg without a death. An examination of all statistics will show that the mortality of major amputations is gradually being reduced. If the cases are subtracted in which death resulted from shock and the loss of blood, the mortality of all major amputations will

* Annals of Surgery, vol. xxii., p. 358.
† Page: London Lancet, 1895, i., p. 923.
‡ Bruns: Beiträge z. klin. Chir., vol. xxii., p. 2.

be reduced to about 4 per cent., as has been the case with the statistics published by Estes.

It is not the least important achievement of Malgaigne to have directed the attention of surgeons to the chief causes which modify the prognosis in individual cases of amputation, and how, therefore, statistics must vary according to certain now well-known conditions under which they are collated. In a somewhat similar direction were the investigations of Simpson. The conditions which influence the prognosis of amputations will now be considered in the order of their importance.

Age.—The mortality of amputations is determined more by age than by any other one factor, since they are better borne in childhood and adolescence than later in life. Malgaigne was the first to point this out by the tabulation of 560 cases in which the mortality steadily increased with the age of the patients. Amputations between the ages of five and fifteen years yielded a mortality of 33 per cent., those between fifty and sixty-five one of 71.4 per cent. Similar investigations have been made by Callender, Holmes, Bryant, and Golding Bird in England, and by Morton and Ashhurst in this country. The last-mentioned author has combined the statistics from various sources, and, after the manner of Mr. Holmes, he has divided life into three periods of twenty years each. The total number of cases thus tabulated is summarized as follows:

TABLE SHOWING PERCENTAGE OF MORTALITY AT DIFFERENT AGES.

Whole number of cases.	Mortality below 20 years.	Mortality between 20 and 40.	Mortality over 40 years.	General death rate.
2,649	16.7	30.1	43.4	29.4

TABLE SHOWING PERCENTAGE OF MORTALITY BEFORE AND AFTER THIRTY YEARS OF AGE.

Whole number of cases.	Mortality below 30 years.	Mortality above 30 years.	General death rate.
1,805	19.2	37.4	26.7

The comparatively excellent results after amputations in children must be attributed to the rapidity with which even large wounds unite in them, to the resistance which their ordinarily unvitiated constitutions offer to septic processes, and to their freedom from visceral complications. The ease with which even large amputations are supported in childhood was particularly impressed on the mind of the writer by the case of a lad of seven, in whom he had amputated below the shoulder for railway injury. Because he was not given the freedom of the ward, the boy escaped from the hospital (Good Samaritan, in Cincinnati) on the eighth day after the operation. The wound had healed *per primam.*

The very unfavorable results which follow amputations in advanced life are readily accounted for by the reduced vitality of the system at large, by the imperfect nutrition of the stump from impaired integrity of the blood-vessels, and by the rapidity with which these patients succumb to septic infection. It is extremely probable that if the latter could be prevented the marked influence of advanced life on the results of amputations would be materially lessened. Thus of sixty-one uncomplicated amputations made by Volkmann, in persons over fifty, only 4.8 per cent. died. Among these was a successful amputation of the thigh for injury in a man eighty-four years of age.

Seat of Operation.—The danger of an amputation always increases with the size of the wound and its proximity to the trunk—amputations of the lower extremity yielding a greater mortality than those of the upper. Since about thirty-two per cent. of the deaths following amputations are directly attributable to the combined shock and hemorrhage consequent upon the injury and the operation, it is easily understood why the mortality varies in the manner indicated. The dangers of septic infection also increase with the size of the wound, and when amputation wounds fail to unite by primary union, death often results from the exhaustion consequent upon protracted suppuration. The situation at which the bone is divided also materially influences the result. The opening of the medullary cavity of a large bone like the femur, or tibia, is more apt to be followed by osteomyelitis and its consequences than is the division of the bone through its articular end. This is well shown by a comparison of the results of amputation through the lower third of the thigh and through the femoral condyles, the former operation yielding a mortality of 39 per cent. against 29 per cent. of the latter.

The ratio of deaths following amputations for injury and disease in different parts of the body is well illustrated in a subjoined table which is based upon large hospital reports, issued from 1864 to 1884. For exceptional operations (hip joint and elbow) reports of cases from private practice were included. This doubtless explains the apparently greater mortality of amputation of the thigh than of the hip, since relatively more successful than unsuccessful cases are thus recorded.

TABLE I. (From Max Schede).

	AMPUTATIONS FOR INJURY.			AMPUTATIONS FOR DISEASE.		
	Total number of cases.	Number of deaths.	Mortality per cent.	Total number of cases.	Number of deaths.	Mortality per cent.
Amputation—						
at hip joint	55	39	70.9	153	65	42.6
of thigh, upper third	73	57	78.0	42	15	35.7
of thigh, middle third	67	50	74.6	137	55	40.1
of thigh, lower third	149	74	50.0	205	64	31.0
of thigh, through condyles	136	44	32.3	79	20	25.4
of thigh, locality not specified	1,384	664	48.	2,494	817	32.7
at knee	314	103	32.8	123	30	24.4
of leg, up. and middle third	130	54	41.5	178	44	24.7
of leg, lower third	33	3	9.1	128	19	14.0
of leg, locality not specified	1,956	785	40.	1,695	215	12.7
of foot, partial	225	45	20.2	562	70	12.4
at shoulder joint	274	116	42.3	118	33	28.0
of arm	1,167	364	31.2	441	81	18.4
at elbow joint	23	6	26.	8	1	12.5
of forearm	1,316	143	10.8	506	62	12.2
at wrist	199	5	2.5	27		
of fingers and toes	337	6	1.8	329	6	1.8

Nature of Lesions.—Very potent in its influence on the results of amputations are the causes for which they are made. When the operation is resorted to in an individual who, while in perfect health, has received a severe injury from which he has probably lost a considerable amount of blood, the prognosis is much less favorable than when it is made for disease. This applies particularly to amputations after railway injuries and traumata inflicted by heavy machinery. The shock and hemorrhage are very often so severe that death results within a few hours after the operation. The prejudicial effect of a trauma on the results of amputations is still further enhanced if the subject is addicted to intemperate habits. This was well illustrated in our recent riots (Cincinnati, 1884). Those injured were for the most part more or less under the influence of alcohol when wounded, and four-fifths of those on whom amputations were made succumbed.

It will be seen from the table given below that the statistics indicate with remarkable uniformity the greater mortality of amputations when made for injury than when made for disease. The explanation generally offered for this feature of the prognosis of amputations is that patients who have for a long time been subjected to suppurative processes (necrosis, caries, etc.), are so inured to suffering that they bear the shock of an operation comparatively well, and that they are less prone to septic infections which are so often the immediate cause

of death after amputations for trauma. The correctness of this view is substantiated by the fact that about seventy-five per cent. of so-called pathological amputations are made for chronic inflammatory conditions of either bones or joints, and that under these circumstances the soft parts are usually more or less atrophied, and yet at the same time densely infiltrated with a connective-tissue growth which, when divided in an operation, presents a barrier to the absorption of deleterious elements. It is noteworthy, as Mr. Bryant has pointed out, that this infiltration of the soft parts does not necessarily interfere with the ready union of the wound. While amputations for chronic affections of the nature indicated terminate fatally in only 14 per cent. of the cases, those made for deformity and neoplasms present a mortality of 26.8 per cent. and 46 per cent. respectively (Golding Bird and Spence).

TABLE II.

Authority.	Amputations for Injury.			Amputations for Disease.			Total Amputations.		
	Number of cases.	Number of deaths.	Mortality, per cent.	Number of cases.	Number of deaths.	Mortality, per cent.	Number of cases.	Number of deaths.	Mortality, per cent.
Malgaigne[1]	182	117	64	378	182	48	560	299	53
Guy's Hosp. Rep.[2]	447	201	45	679	147	22	1,126	348	31
Chadwick[3]	846	202	24	524	102	19	1,370	304	22
Billroth (1860-67)[4]	106	57	54	58	18	31	164	75	46
Wilms[5]	144	58	40	94	32	33	238	90	38
Lücke[6]	28	21	75	52	25	48	80	46	57
Volkmann[7]	130	24	19	187	7	3	317	31	9+
Ashhurst[8]	72	24	33	28	4	14	100	28	28
Spence[9]	186	77	41	371	73	19	557	150	27
Glasgow Inf.[10]	388	126	32	338	40	12	726	166	23
Leeds Inf.[11]	355	84	24	305	48	16	660	132	20
St. George's Hosp.[12]	159	72	46	409	99	24	568	171	30
St. Barth. Hosp.[13]	115	33	29	424	55	13	539	88	16
Total	3,158	1,096	34.7	3,847	832	21.6	7,005	1,928	27.5

[1] Malgaigne: Arch. gén. de méd., 1842, 14, p. 52.
[2] Guy's Hospital Reports, published statistics of vol. xxi., 3d S., to which cases since reported have been added.
[3] Amputation, statistics of, in four American hospitals.
[4] Statistics of Surg. Clinic of Zürich. Langenbeck's Arch. f. Chir., vol. x.
[5] P. Güterbock: Statistics of Bethanien. Langenbeck's. Arch. f. Chir., vol. xxii., p. 80.
[6] Lücke: Statistics of Hospitals of Berne. Zeitschr. f. Chir., vol. ii., p. 380.
[7] M. Oberst: Die Amputationen in d. Volkmann'schen Klinik. Halle, 1882. Statistics rearranged to suit this table; 57 complicated cases with 17 deaths are included.
[8] Ashhurst: Encyclop. of Surg., vol. i.
[9] Spence: Med. Times and Gazette; Edinb. Med. Journ. Ashhurst in Internat. Encyl. of Surg., vol. i.
[10] Amputations for eight years, ending December 31, 1881, M. Thomas: Lancet, 1882, vol. i., p. 1067.
[11] Amputations in the Leeds Infirmary by Thomas Nunnely, Lancet, 1870, vol. i., p. 153.
[12] T. Holmes: St. George's Hospital Reports, vols. i. and viii. Also vols. ix. and x.
[13] St. Bartholomew's Hospital Reports, vol. xix., Stat. Tables, p. 92.

TABLE III.—MAJOR AMPUTATIONS DONE AT THE CINCINNATI HOSPITAL FROM JANUARY 1, 1890, TO JANUARY 1, 1900.

	Injury.				Disease.			
	Recovered.	Died.	Total.	Per cent.	Recovered.	Died.	Total.	Per cent.
Leg	54	3	57	5.2	22	2	24	8.3
Knee	4	..	4	..	2	1	3	33
Thigh	11	5	16	31.3	17	3	20	15
Hip	..	..	..	..	1	..	1	
Wrist	2	..	2	..	..	..		
Forearm	11	1	12	8.3	3	..	*3	
Elbow	..	..	..	..	..	..	..	
Arm	11	..	11	..	3	..	3	
Shoulder	2	4	6	..	1	..	1	
Total	95	13	108	13.7	49	6	55	10.9

* One multiple injury.

TABLE IV.—AMPUTATIONS DONE DURING TWELVE YEARS PRIOR TO 1895, NEWCASTLE-ON-TYNE. (PAGE.)

	Number.	Recovered.	Died.	Per cent.	Number.	Recovered.	Died.	Per cent.
Double amputation	13	7	6	46				
Hip joint	6	3	3	50	23	14	9	39
Thigh	52	39	13	25	154	144	10	6.4
Knee	7	7	..	..	2	2		
Leg	76	69	7	9.2	70	67	3	4.2
Ankle	26	25	1	3.8	122	120	2	1.6
Shoulder	17	16	1	5.8	15	14	1	6.6
Arm	37	34	3	8.1	18	17	1	5.5
Forearm	36	35	1	2.8	31	31		
Wrist	7	7						
Total	277	242	35	12.6	435	409	26	5.9

Tables III. and IV., while they show the great reduction in the mortality of amputations in general, still demonstrate the greater mortality of operations done for trauma. That the difference is not so marked in my own table (III.) is due to the fact that many of the pathological amputations were made for senile gangrene.

MULTIPLE AMPUTATIONS.—While it is comparatively rare that disease or injury affects more than one extremity in a degree sufficient to warrant double amputations, these are nevertheless occasionally required. It is self-evident that they are of the gravest importance and present a most unfavorable prognosis, on account of the shock associated with the injury. Of 28 double amputations made in the Western Pennsylvania Hospital, 27 were for railroad accidents, and 15 of the patients died. The fact that 11 of the deaths occurred in the first forty-eight hours shows that they were due rather to the injuries than to the amputations. Of 13 multiple amputations done for injury at the Newcastle Infirmary 6, or 46 per cent., died. When multiple amputations are made for disease, which is in about 10 per cent. of all cases, it is usually for frost-bite.

MULTIPLE AMPUTATIONS IN MILITARY PRACTICE.

	Number of cases.	Recovery.	Deaths.	Undetermined.	Per cent. of mortality.
Both amputations in the upper extremity	47	31	16	..	34
One amputation in upper, one in lower extremity	43	21	21	1	50
Both amputations in lower extremity	82	31	50	1	61.7
Total	172	83	87	2	51.1

MULTIPLE AMPUTATIONS IN CIVIL PRACTICE.

	Number of cases.	Recovered.	Died.	Mortality, per cent.
Thighs	18	3	15	83
Thigh and leg	21	9	12	57
Thigh and arm	5	2	3	60
Thigh and forearm	7	4	3	43
Leg and leg	42	20	22	52
Leg and arm	11	6	5	45
Foot and foot	12	10	2	16
Arm and arm	9	6	3	33
Forearm and forearm	15	11	4	27
Total	140	71	69	49

The mortality attending multiple amputations, it will be seen from the preceding tables, is about fifty per cent., amputations through the lower extremities presenting a greater fatality than those of the upper. The first table illustrates the mortality of these amputations in military practice. The second table, made up from German, English, and American reports, shows the relative frequency and fatality of multiple amputations as they are made in different parts of the body.

When the necessity for multiple amputations arises, the question must be considered whether they shall be made at the same time, when they are called synchronous amputations, or whether a longer or shorter interval shall intervene between them. In these cases, as in amputations generally, no definite rules can be formulated. In cases of trauma it is generally advisable to make both amputations at the same time, removing the larger member first, but deferring the closure of the wound until both amputations are completed. If, after the first operation, the condition of the patient is such as to preclude the possibility of recovery if the second is performed at once, the less injured member must be treated as if the injury sustained by it were of a less degree of severity and justified an attempt at conservatism. In cases of disease affecting several extremities (frost-bite, white swelling, etc.), it is generally better to observe a sufficient interval between the operations to permit the constitution to rally from the first before the second amputation is made. In these cases the danger of septic infection from the limb that is spared is not as great as in cases of traumatic origin.

Even triple and quadruple amputations are occasionally performed with success. In a case of railway accident, Dr. G. Koehler, of Schuylkill Haven, Pa., in 1867, removed simultaneously, on account of a railway injury, both legs and one arm from a lad thirteen years of age, recovery taking place. Professor Stone, of New Orleans, had a similar case in a man of thirty, the subject of a railway accident. According to Professor Agnew, successful triple amputations were made in York, Pa., in 1868, and Rochard reported to the Academy the case of De Leseleuc, of Brest, who had successfully amputated a thigh, leg, and arm in a man the subject of trauma Quadruple amputations, usually made for frost-bite, have been successful in the cases of Muller, of the United States army, Dr. Begg, of Dundee, and M. Champenois, of the French army. Other cases are referred to by Morand, Longmore, and Southam. M. Larrey mentions two cases, one of which, the case of a soldier who had all his extremities removed by heavy ordnance, he had seen in the "Invalides." The other case, which he had seen in Algiers, was that of an Arab, twelve years of age, who had intentionally placed himself on the track in such a position that a passing train mangled both hands and feet. Still another successful quadruple amputation for frost-bite has recently been recorded by Tremaine.

Individual Amputations.

Amputation of the Fingers.—When the phalanges of the fingers or thumbs are the seat of incurable disease or of severe injury, amputation often becomes necessary. It is well to remember that if the bone of the distal phalanx alone is affected, its natural exfoliation should be awaited, when the soft parts can often be preserved, to the great advantage of the patient. Particularly in the thumb and index finger is it necessary to save as much as possible. In the third and fourth fingers amputation should not be practised at the second joint, since the preservation of the proximal phalanx leaves a part that is ungainly and does not add to the usefulness of the hand. When a portion of a finger requires removal the operation may be practised either at a joint or in the continuity of a phalanx. In both cases it is important to remember that when the finger is flexed the articulations are below the prominences made by the knuckles, the distal, middle, and proximal articulations being respectively one-sixth, one-fourth, and one-third of an inch below the most prominent lines of the joints. It must also be borne in mind that strong lateral ligaments prevent, until they are divided, the complete exposure of articular surfaces (Fig. 136). When the amputation is to be made at the joint, it can be most expeditiously executed in the following manner: The hand being held in the prone position, the tip of the finger, encased in a piece of gauze, is firmly seized by the operator and flexed. With a long and narrow knife an incision is made from side to side over the dorsal surface. By this the joint is at once opened. With two rapid strokes of the point of the knife the lateral ligaments are next severed. The blade of the knife, with edge directed downward, is then placed behind the flexor surface of the phalanx to be removed, from the soft parts of which a well-rounded flap is to be cut from within outward by a sawing movement. The wound presents the appearance shown in Fig. 137. Only when there is an insufficiency of flap is it proper to remove the head of the proximal bone. The disarticulation of a phalanx can also be effected by transfixion: the hand being held in a supine position and the finger extended, the latter is transfixed on the palmar side of the bone, just below the fold of the joint; a palmar flap of sufficient length is then made. The flap being held out of the way, the joint is made prominent by hyperextension and opened. The soft parts on the dorsal surface of the joint are then divided by a single sweep of the knife. In amputations of the fingers, the soft parts of the palmar aspect are always preferable for a flap, since the cicatrix is then protected from pressure. Where they cannot be utilized, a dorsal flap can be made, either by transfixion or, what is preferable, by cutting from without. Lateral flaps, single or double, can likewise be utilized in this amputation. In amputations in the continuity of a phalanx the flap may be cut from the palmar aspect by a transfixion, the dorsal surface being divided by a transverse incision, or a second flap may be formed. The circular operation, with longitudinal lateral cuts, may likewise be successfully practised in this position. After the division of the soft parts, the bone must be divided with a metacarpal saw or the cutting forceps. In all amputations of the fingers two digital arteries usually "spirt." Their ligation is unnecessary; the approximation of the wound surfaces generally suffices for their closure.

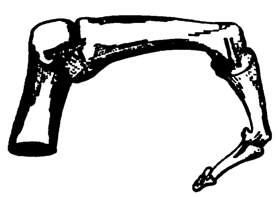

Fig. 136.

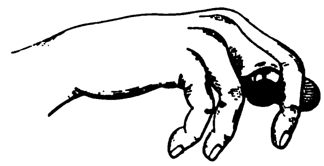

Fig. 137.

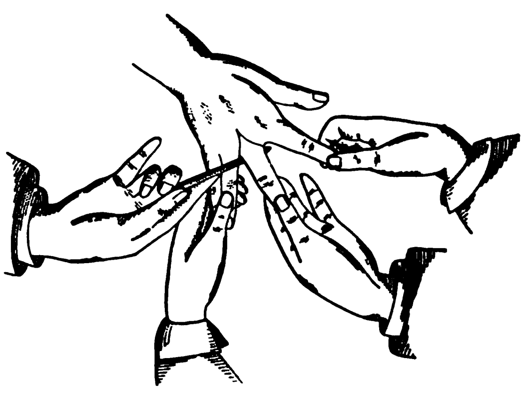

Fig. 138.

Amputation of an entire finger at the metacarpo phalangeal joint can be readily accomplished as follows: The adjacent fingers being held aside by an assistant, the operator, with his back to the patient, grasps the finger to be removed with the left hand and extends it sufficiently to see its palmar surface. A narrow knife being introduced from the right side divides the soft parts on

surface on a level with the extended inter-
). The incision is then carried around the
of the finger (Fig. 138, Esmarch) in a slight
the dorsal surface of the head of the meta-
e. The knife is then carried around the left
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han strength, it is best to remove the head of
tacarpal bone with cutting forceps (Fig. 139), since its preservation usually leaves an unsightly prominence. In persons who do manual labor its removal should be avoided, since it would materially lessen the strength of the hand.

FIG. 139.

The incisions for disarticulations of the thumb, index and little fingers may often be advantageously modified in such a manner as to make two lateral flaps, the longer of which is on the free side of the finger, the shorter being made on the side of the interdigital web. To preserve the symmetry of the hand, the heads of the second and fifth metacarpal bones should always be removed by an oblique section when the index and little fingers are amputated. When two or more fingers are to be removed, it can easily be done by making two convex flaps, one on the dorsal and the other on the palmar aspect of the hand, the latter being given the greater length. A flap may likewise be taken from the side of one finger, or rectangular flaps from the opposite surfaces of the fingers that are farthest from each other. In amputations of a number of fingers it is generally best to remove each finger separately, since unnecessary sacrifices for the sake of brilliancy will thereby be avoided and a better result be obtained. When, in consequence of accident or disease, the metacarpal bone must be removed with the finger, the incisions are like those for the removal of an entire finger, only that the dorsal cut must be continued upward toward the wrist for a varying distance, and that the incision around the root of a finger is to be made above the interdigital web. The extensor tendons being divided as high as possible, and the bone separated from its muscular attachments, this is divided with cutting forceps near its articular extremity or entirely enucleated. When the surgeon has the option, the former practice should be preferred, to avoid opening the articulations of the wrist. Exceptions can be made in the first and fifth metacarpal bones, which, having individual synovial sacs, may be removed without the danger of producing extensive inflammation of the wrist. Amputation of the entire thumb should rarely be practised, for every portion of it that can be saved is of value for opposition to the fingers. When

FIG. 140.

it becomes necessary to remove the thumb with its metacarpal bone, it is best accomplished by the oval method. The point of a knife should be entered above its articulation with the carpus, and a triangular incision (Fig. 140) made along its radial aspect, the sides of the triangle diverging from each other as they approach the

FIG. 141.

head of the metacarpal bone and becoming continuous with each other in the web and index finger. The muscles being detached and the extensor tendons divided, disarticulation is readily effected by forcibly extending the thumb toward the radial side and severing the ligaments. In disarticulating, the edge of the knife should be kept close to the base of the bone, lest the joint between the second metacarpal and trapezium, and through it the remaining carpal joints, be opened. After this operation a linear cicatrix remains. The most expeditious method of amputating the thumb yet devised is that of Walther, and is admirably suited to cases in which an anæsthetic is not used. The thumb being abducted, the knife is made to cut its way between the first and second metacarpal bones until the base of the former is reached (Fig. 141). The thumb being greatly abducted, the joint between its metacarpal bone and trapezium is opened and traversed. The knife is then carried downward upon the radial side of the bone, where, by cutting outward to the level of the interdigital web, a radial flap is made. Amputations of the little finger with its metacarpal bone can be made in the same manner, either by the oval or by the flap method.

FIG. 142.

Injuries of the palm of the hand are generally of such a nature that by a little ingenuity on the part of the surgeon part of it can be preserved. When in rare cases disarticulation of the last four metacarpal bones becomes necessary, the thumb being left, it may be done as follows: The hand being grasped and held in supine position, a long, narrow blade is
through the palm from the base of the fifth meta
bone to the web of the thumb. By cutting outv
broad semilunar flap is made (Fig. 142). An inc
next made on the back of the hand, beginning at
of the thumb and carried obliquely upward to th
third of the second metacarpal bone, whence it
tinued transversely over the three last metacarp
until it meets the palmar flap at the ulnar bord
hand. Both flaps are thus reflected to the ca
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ulnar side, the hand being forcibly abducted.

AMPUTATION AT THE WRIST.—In amputati
wrist the surgeon has the choice of the ci
the tegumentary flap methods, both of whi
excellent stump.

Circular Method.—Retracting the skin of the forearm with his left hand, the operator carries the knife in a circular sweep around the hand one inch below the styloid processes. The skin and subcutaneous layers, being

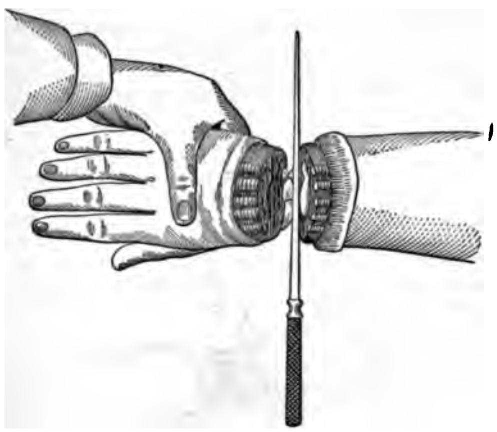

FIG. 143.

liberated by incisions perpendicular to the axis of the limb as far as the styloid processes, should be reflected like a cuff. The hand being then pronated and forcibly flexed, the tendons are divided and the joint opened by an incision over the dorsum from one styloid process to the other. In making this incision the convexity of the upper surface of the carpus must be remembered. The lateral ligaments being next severed, the anterior part of the capsule and all the flexor tendons are cut through with one stroke of the knife (Fig. 143).

Antero-posterior Flap.—The operator seizes the lower part of the pronated hand, and after flexing it makes a semilunar incision over the middle of the back of the hand from one styloid process to the other (Fig. 144). After reflection of the flap the joint is opened as in the circular operation, and the operation is completed by cutting a short palmar flap from within outward (Fig. 145). The projection of the pisiform bone often renders this part of the operation embarrassing.

FIG. 144.

Method of Dubreuil.—A very excellent result can be obtained by making a single lateral flap, either from the radial surface of the thumb or from the soft parts covering the fifth metacarpal bone, the former being preferable. As will be seen from Fig. 146, the operation consists in making a semilunar flap with broad base, from the integument which covers the first metacarpal bone, the point of the flap reaching the base of the first phalanx. A transverse incision around the wrist is then made and disarticulation is completed as in the other operations.

AMPUTATION OF THE FOREARM may be practised by the circular, tegumentary, or musculo-tegumentary flap method. The lower third of the forearm, containing a large number of tendons, is ill suited for the latter method, the circular operation being preferable (Fig. 147). When the integument is greatly infiltrated and the reflection of a cuff is thereby rendered impracticable, tegumentary flaps can be made, the tendons being divided by a circular incision (Fig. 148). The presence of a large number of synovial sheaths, and the danger of inflammation in them when they are opened should not militate against the value of operations in the lower third of the forearm, since, by operating below the insertion of the *pronator radii teres*, movements of pronation and supination will be preserved.

A number of surgeons prefer the flap operation in all amputations of the forearm, making both flaps by transfixion in fleshy subjects. Under opposite circumstances the anterior flap can be made in this manner, and the posterior by cutting from within outward. When this method is resorted to, the bones must be divided as high up as possible, to overcome their tendency to protrude at the angles of the wound. Musculo-tegumentary flaps should be used only in the fleshy part of the forearm. In all amputations in this part the catling is to be used, in the manner already described (Fig. 123). The divided tendons and nerves must be drawn from the wound and cut as short as possible. The arteries requiring ligation are the radial, ulnar, and interosseous. It is particularly essential that the latter should be divided *but once*, and carefully secured. When secondary hemorrhage occurs after amputation of the forearm, it is almost always the result of faulty ligation of this vessel.

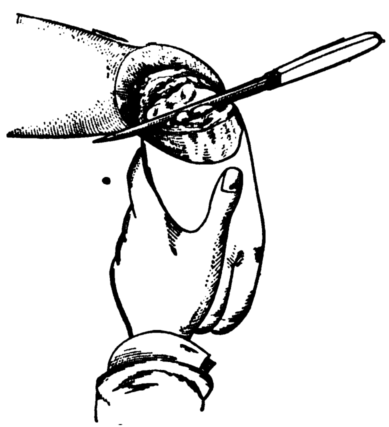

FIG. 145.

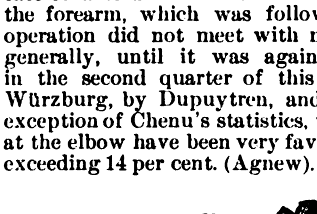

FIG. 146.

AMPUTATION AT THE ELBOW.—The removal of the forearm at its articulation with the humerus is generally acknowledged to have been first performed by Ambrose Paré, in 1536, in the case of a soldier who had received a gunshot wound of the forearm, which was followed by gangrene. The operation did not meet with much favor by surgeons generally, until it was again advised and practised in the second quarter of this century by Textor, of Würzburg, by Dupuytren, and by Liston. With the exception of Chenu's statistics, the results of amputation at the elbow have been very favorable, the death rate not exceeding 14 per cent. (Agnew). The last-named writer, however, gives a mortality of 65 per cent. as that which attended disarticulations of the forearm during the Crimea. On the other hand, of 39 amputations at the

FIG. 147.

the palmar surface on a level with the extended interdigital web. The incision is then carried around the right side of the finger (Fig. 138, Esmarch) in a slight curve into the dorsal surface of the head of the metacarpal bone. The knife is then carried around the left side of the finger in the same manner, the ends of the first incision being thus joined. The tendons, lateral ligaments, and capsule being successively divided, the disarticulation is completed and a heart-shaped wound left. The margins of this wound come accurately into contact when the remaining fingers are approximated to one another. When comeliness of the hand is valued more than strength, it is best to remove the head of the metacarpal bone with cutting forceps (Fig. 139), since its preservation usually leaves an unsightly prominence. In persons who do manual labor its removal should be avoided, since it would materially lessen the strength of the hand.

FIG. 139.

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FIG. 140.

it becomes necessary to remove the thumb with its metacarpal bone, it is best accomplished by the oval method. The point of a knife should be entered above its articulation with the carpus, and a triangular incision (Fig. 140) made along its radial aspect, the sides of the triangle diverging from each other as they approach the

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AMPUTATION AT THE WRIST.—In amputations at the wrist the surgeon has the choice of the circular and the tegumentary flap methods, both of which leave an excellent stump.

Circular Method.—Retracting the skin of the forearm with his left hand, the operator carries the knife in a circular sweep around the hand one inch below the styloid processes. The skin and subcutaneous layers, being

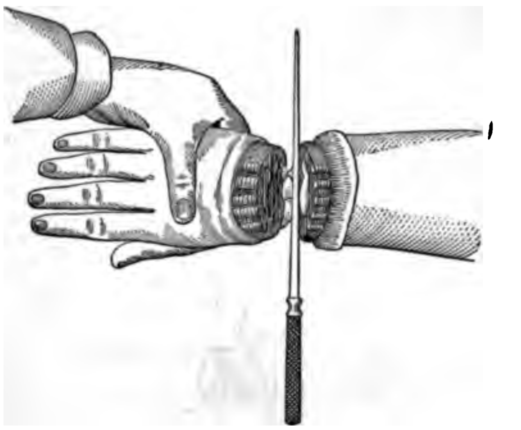

FIG. 143.

liberated by incisions perpendicular to the axis of the limb as far as the styloid processes, should be reflected like a cuff. The hand being then pronated and forcibly flexed, the tendons are divided and the joint opened by an incision over the dorsum from one styloid process to the other. In making this incision the convexity of the upper surface of the carpus must be remembered. The lateral ligaments being next severed, the anterior part of the capsule and all the flexor tendons are cut through with one stroke of the knife (Fig. 143).

Antero-posterior Flap.—The operator seizes the lower part of the pronated hand, and after flexing it makes a semilunar incision over the middle of the back of the hand from one styloid process to the other (Fig. 144). After reflection of the flap the joint is opened as in the circular operation, and the operation is completed by cutting a short palmar flap from within outward (Fig. 145). The projection of the pisiform bone often renders this part of the operation embarrassing.

FIG. 144.

Method of Dubreuil.—A very excellent result can be obtained by making a single lateral flap, either from the radial surface of the thumb or from the soft parts covering the fifth metacarpal bone, the former being preferable. As will be seen from Fig. 146, the operation consists in making a semilunar flap with broad base, from the integument which covers the first metacarpal bone, the point of the flap reaching the base of the first phalanx. A transverse incision around the wrist is then made and disarticulation is completed as in the other operations.

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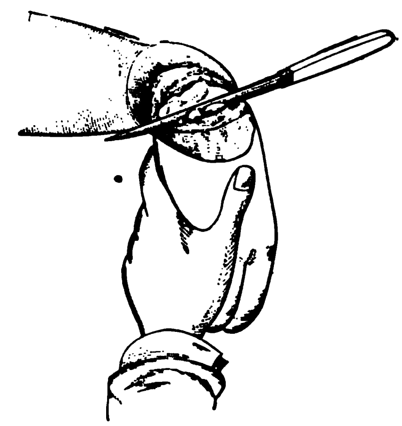

FIG. 145.

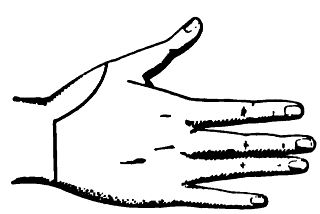

FIG. 146.

AMPUTATION AT THE ELBOW.—The removal of the forearm at its articulation with the humerus is generally acknowledged to have been first performed by Ambrose Paré, in 1536, in the case of a soldier who had received a gunshot wound of the forearm, which was followed by gangrene. The operation did not meet with much favor by surgeons generally, until it was again advised and practised in the second quarter of this century by Textor, of Würzburg, by Dupuytren, and by Liston. With the exception of Chenu's statistics, the results of amputation at the elbow have been very favorable, the death rate not exceeding 14 per cent. (Agnew). The last-named writer,

FIG. 147.

however, gives a mortality of 65 per cent. as that which attended disarticulations of the forearm during the Crimea. On the other hand, of 39 amputations at the

elbow, made during the War of the Rebellion, in which the result was determined, only 3 succumbed; the mortality being less than 8 per cent.

The operations generally resorted to in amputations at the elbow are the circular and musculo-tegumentary flap methods. When the former is practised, a circular incision should divide the skin and subcutaneous cellular layer of the forearm at least two inches below the humeral condyles. When a cuff of sufficient length has been reflected, the anterior surface of the joint is made prominent by hyperextension, and divided by a transverse cut with the end of the knife. When the lateral ligaments are next divided, the joint surfaces are sufficiently separated from each other to permit the knife to be passed behind the olecranon, where the tendon of the triceps is to be divided. The latter step of the operation is sometimes attended with such difficulty that many surgeons preserve the olecranon process by sawing the ulna transversely after disarticulation of the radius has been effected. The advantages which are to be obtained by its preservation, on account of the influence which the triceps will have over the artificial limb, are more than balanced by the increased dangers of retention of secretion in the wound and necrosis.

FIG. 148.

Excellent results can also be obtained by tegumentary flaps. As represented in Fig. 148 (Esmarch), a curved incision is made over the flexor surface of the forearm, beginning and ending about one inch below the condyles. The large semilunar flap thus made is reflected to its base. A second, but shorter convex flap is made posteriorly, which, when reflected, exposes the olecranon. The operation is then completed by disarticulation, as in that by the circular method. The most brilliant operation, and at the same time a very satisfactory one, is that by which a long anterior flap is made by transfixion. The knife, being introduced a little less than an inch below the external condyle (for the right arm) of the humerus, is pushed directly across the front of the articulation to a point on the same level on the opposite side. The arm being held in a supine position, a broad, almost rectangular flap, from four to five inches in length, is made by cutting outward. The ends of the wound should then be united by a slightly convex incision carried across the posterior aspect of the joint. Disarticulation is then effected as in the previous operations.

When the soft parts of the anterior portion of the forearm cannot be utilized, the integument of the posterior surface can be shaped into an admirable covering for the end of the bone. Ashhurst thus describes the elliptical incision by which this is accomplished: "The arm being semiflexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upward over the front of the forearm nearly to the line of the joint, and downward again to a point an inch and a half below the external condyle; the arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon. The cuff thus marked out is rapidly dissected upward as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side. The wound is closed transversely, forming a small curved cicatrix in front of the bone."

It is probably always advisable, except in cases of disease, to preserve the articular surface of the humerus intact, although Sir William Ferguson believed that a section above the condyles leaves a preferable stump, and one more likely to heal promptly. In all amputations at the elbow, the radial, ulnar, and interosseous arteries require ligation. When the incision through the soft parts anteriorly is made on a higher level than is ordinarily necessary, the brachial may be divided and require ligation.

AMPUTATION OF THE ARM.—This may be performed at any point below the axillary folds, and all the methods of amputating may be used with advantage in different cases, since the choice of methods often permits the

FIG. 149.

operator to save a considerable portion of the arm. On account of the central position of the humerus, the arm is properly considered the typical position for the double musculo-tegumentary flap operation by transfixion, and many surgeons prefer this method in this situation. The objection to be urged against it is the unequal retraction of the integument and underlying muscles, the latter generally protruding a varying distance over the cutaneous margins of the wound. Agnew properly advises that, to overcome this unequal retraction, antero-posterior oval skin flaps should be raised of sufficient length to compensate for the difference in muscular and cutaneous retraction; after these are made, the muscular flaps are formed either by transfixion or by cutting from within outward. The latter plan of operating, although less brilliant than that by transfixion, should always be preferred in amputations of the arm in very fleshy sub-

FIG. 150.

jects. In making the flaps, the posterior should always be made first, the anterior, containing the important vessels and nerves, being made last. According to the dimensions of the limb, the flaps should be made from two to three inches in length.

In slender subjects, the circular operation answers admirably. In exceptionally thin arms, the integument can be retracted sufficiently to make the operation by a single circular incision. As a rule, however, it is best formally to reflect a cuff (Fig. 149), or to make rectangu-

lar cutaneous flaps by slitting the cuff on each side. In dividing the muscles by a circular incision, the biceps generally retracts more than the remaining muscles. The wound is often so irregular in consequence that a second division of the muscles becomes necessary (Fig. 150). In cases of injury attended with great destruction of the soft parts on the dorsal aspect of the arm, the Teale method, by rectangular flaps, offers particular advantages. The incisions for making the long anterior flap must be made in such a manner that the inner one shall be without the brachial artery, which should be contained in the short posterior flap.

In amputations through the middle and lower thirds of the arm, the circulation can be controlled in the ordinary manner by the Esmarch tube or tourniquet. In amputations higher up, where the tourniquet would be in the way of the operator, and liable to slip, the main artery can be compressed against the head of the bone by an assistant, or against the first rib above the clavicle. When a tourniquet is used in amputations in the upper part of the arm, it should be so applied that a roller covers the axillary artery in the arm-pit, while the plate of the tourniquet can be fixed against the acromial process of the scapula. The arteries requiring ligation after amputation of the arm are the brachial, superior or inferior profunda, occasionally the anastomotica, and four or five muscular branches. It should be remembered, likewise, that in every fifth subject, according to Quain, there is a high division of the brachial into radial and ulnar.

In 5,273 cases of amputation of the arm for gunshot injury, 1,246, or 23.6 per cent., terminated fatally. The gravity of amputation of the arm does not increase with the extent of the limb removed, amputations through the lower third presenting a mortality of 35 per cent. against 19 per cent. for amputations in the middle and 22 per cent. for those of the upper third. In the statistics of Gorman, derived from civil practice, this remarkable feature in the prognosis of amputations of the arm is even more pronounced, the mortality following amputations in the upper, middle and lower thirds being 23 per cent., 21 per cent. and 44 per cent. respectively. Of 14 amputations of the arm in the Cincinnati Hospital all recovered. Of 157 amputations of the arm collected from the recent statistics of Erdman, Page, and my own, 20, or 12.8 per cent., died. For the comparative mortality after amputations of the arm for injury and for disease, the reader is referred to Tables I., II., and III.

Amputation at the Shoulder.—Although this operation was referred to by ancient writers on medicine, it was not performed as a formal operation till 1710, when the elder Morand performed it with a fatal result in a case of caries. The case was not recorded until some years later, by the younger Morand. The second operation, which was successful, was made in 1715 by the elder Le Dran, likewise for caries. That the arm had previously been removed at the shoulder in a case

Fig. 151.

of gangrene appears in the *Jour. de Méd. de M. De la Roque*, 1686. "The surgeon took a small saw to remove the bone of the arm, but perceiving that it was loose in the joint, he gave it several slight 'jerks,' when the bone was readily drawn from the socket." Ravaton, La Faye, Heister, and Bromfield repeated the operation from time to time on the Continent and in England, but it remained for the distinguished Larrey to give it a firm footing among surgical procedures. Of 111 amputations made by him at this part, 97 recovered.

In all amputations of the shoulder, the circulation in the axillary artery must be controlled. This can be ac-

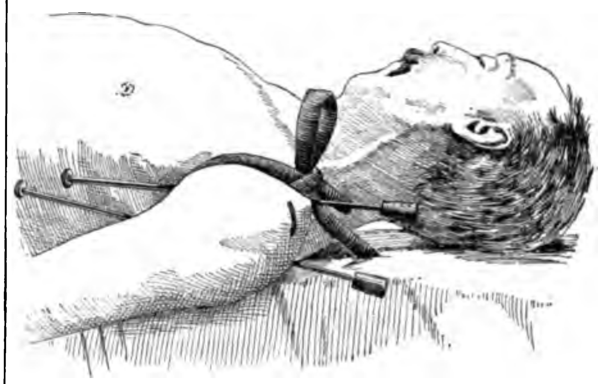

Fig. 152.—Showing Wyeth's Pins and the Rubber Tubing in Place. A piece of black court plaster indicates the tip of the acromion. (Taken, by permission, from Keen's article on shoulder amputations, in the Transactions of the American Surgical Association for 1894.)

complished by the use of the rubber tube of the Esmarch bandage firmly wound around the axilla and shoulder, and held by an assistant or clasped toward the neck of the patient (Fig. 151). To prevent the slipping of the strap, which is likely to occur when the head of the humerus leaves the socket, two long transfixion pins may be used, the one in front of and the other behind the acromion. The anterior pin is introduced through the middle of the anterior axillary fold near the trunk line. It is made to emerge an inch above the shoulder, one inch to the inner side of the acromial tip. The second pin transfixes the posterior axillary fold in the same manner, emerging behind the acromion (Fig. 152). In all amputations of the shoulder the joint should be approached from the outer side, so that the artery shall not be divided until disarticulation has been effected. In this manner an assistant can, if necessary, pass his thumb into the wound above the knife (Fig. 153) and compress the vessel before it is cut. Two pairs of pedicle clamp forceps with blades three inches long applied above the line of division of the inner flap, the one from in front and the other from behind, will perfectly control the artery while the operation is being completed. Thereby skilled assistance, and even the Esmarch strap, can be dispensed with. The hemorrhage is from the smaller vessels only and is slight. When the axilla is invaded so high that this plan of hæmostasis is impracticable, the axillary should be tied by dividing the pectoral muscle as suggested by Delpech, or the subclavian should be tied in its third part, as a preliminary step to the amputation. When such precautions as have been described can be taken, it is not necessary to make a preliminary ligation of the artery in the axilla. Amputations at the shoulder joint can be made by the oval or flap method, and likewise by a circular operation with external longitudinal incision.

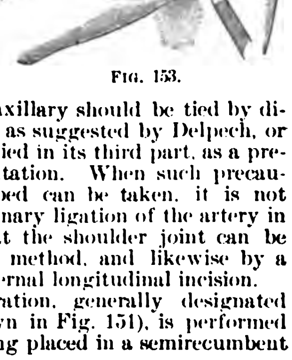

Fig. 153.

Oval Method.—This operation, generally designated Larrey's operation (as shown in Fig. 151), is performed as follows: The patient being placed in a semirecumbent

position, with the part to be amputated projecting over the edge of the operating table, the point of the knife is introduced just beneath the point of the acromion process, and carried down over the external surface for a distance of from two and one-half to four inches, according to the dimensions of the part. This incision should divide all the tissues down to the bone. From the centre of this incision an oval cut is carried around the arm, passing a little below the axillary folds, but involving only the skin and superficial fascia. The flaps thus outlined are carefully liberated from the bone. The capsule is then freely opened by a transverse cut over the head of the humerus, and the arm is rotated inward and outward to facilitate the division of the tendons of the articular muscles; in this part of the operation, the edge of the knife must be kept in close contact with the bone. The operation is completed by dividing the soft parts on the internal surface of the arm on a level with the cutaneous incision already made. While it is not essential, in this operation, to carry the oval incision completely around the arm before beginning the dissection of the flaps, it is preferable, since, without it, the lower part of the oval wound is very apt to be ragged and uneven. The wound following this operation is united so as to leave a linear cicatrix parallel to the axis of the body (Fig. 154, from a photograph of one of Ashhurst's patients).

FIG. 154.

In cases in which the humerus is shattered to such a degree that it cannot easily be used in the manipulations necessary for effecting disarticulation, the following modification of the circular incision will answer admirably: The arm being abducted, a circular incision at the lower border of, or through, the deltoid divides all the soft parts down to the bone. This, if necessary, is divided on the same level, and all the gaping vessels are ligated. When the amputation of the arm is thus completed, a long incision, dividing all the soft parts, is made from the tip of the acromion over the external surface of the shoulder to the circular wound. The remaining stump of the humerus is then seized with a strong pair of forceps, and liberated from its muscular attachments and from the joint by short incisions directed well against the bone (Esmarch).

Amputations at the shoulder by the flap method can be made either by transfixion or by cutting from without inward. The latter method, while less brilliant, is preferable in every way. It should be performed in the following manner: In amputation of the left arm the operator begins his incision at the coracoid process, and carries it down over the anterior surface of the shoulder to the level of the insertion of the deltoid, across which it is carried in a wide curve; it is then prolonged upward on the posterior surface of the shoulder to the junction of the acromion with the spine of the scapula (Fig. 155). This broad flap, including a great part of the deltoid, is then raised by rapid strokes of the knife and reflected over the acromion in order that the joint may be exposed. This is made prominent by pushing the head of the humerus upward, and is to be opened by a transverse cut upon the latter. The head of the bone is now easily dislocated. The knife is then carried behind the humerus (as shown in Fig. 153) and down its inner surface to a point one or two inches below the axillary fold, when, by rapidly cutting outward, all the soft parts on the inner side are divided.

In making this operation by transfixion (Dupuytren's method) the arm must be held at a right angle with the body, while the surgeon grasps and raises the fleshy part of the shoulder with the left hand. The knife is entered one or two inches behind the acromion and pushed directly across the front of the joint, emerging just outside the coracoid process of the scapula. Transfixion being effected, a broad flap is cut from within outward. The further steps of the operation are similar to those above detailed.

Both of the operations described leave a wound that, from its position, is more readily drained than that which is left by the oval method. The cicatrix which remains is transverse in direction and curvilinear.

A wound closely resembling that left by Larrey's oval operation remains after the formation of postero-external and antero-internal flaps by Lisfranc's method. In practising this method, when the left arm is to be removed, a long and narrow amputating knife is introduced at the margin of the posterior axillary fold. The blade is then pushed along the posterior surface of the humerus until the head of the bone has been cleared, when the counter-puncture can readily be made an inch beneath the clavicle and on the outer side of the coracoid process. A broad postero-external flap must then be shaped by cutting from within outward. The capsule is then opened as in other operations, and an antero-internal flap cut likewise from within outward. In operations on the right side the posterior flap is also made first; the surgeon, standing behind the patient, inserts the point of the knife from above and lets it emerge from the posterior axillary fold.

Professor Spence, of Edinburgh, has recently introduced a method of amputating which is but a modification of the oval operation, in which the perpendicular incision is made upon the head of the humerus, nearer to its inner than its outer surface. This incision is commenced just beneath and outside of the coracoid process and carried through the clavicular fibres of the pectoralis major and deltoid muscles until the humeral attachment of the former is reached. From the lower end of this incision the external and internal curvilinear incisions are almost the same as those of the oval operation as generally practised. The advantages claimed by Professor Spence for this modification are the facility with which the disarticulation can be effected, the avoidance of injury to the main trunk of the posterior circumflex artery, and the better shape of the stump.

FIG. 155.

INTERSCAPULO - THORACIC AMPUTATION.—In the first edition of this work 14 cases of avulsion of the entire upper extremity were referred to, which ended favorably. In the last edition of Ashhurst's "Surgery," 17 cases are recorded of such avulsion which ended favorably. Here also are recorded 89 cases, in which the entire upper extremity including the scapula and part of the clavicles was removed by operation, with 67 recoveries and 22 deaths. Bergmann has put on record 14 amputations of the entire upper extremity, with only 1 death. Favorable cases have likewise been recorded by Chavasse, Oehsner, Keen, Doll, and Heddaens. Barling has recently collected 19 cases operated on within five years without a death (*Clin. Soc. Trans.*, xxxi., p. 182). The operation is indicated in cases of severe crush of the upper extrem-

ity when exarticulation at the shoulder would not suffice, and in neoplasms of the upper extremity when it is essential to get as far as possible from the disease. The first operation was done by Cumming, in 1808, for gunshot injury; the second, in 1830, by Gaetani for a severe trauma from an explosion. In 1887 Paul Berger tabulated all of the cases recorded up to that time, and submitted the most comprehensive monograph upon the subject.

As in amputations at the shoulder joint, the control of hemorrhage is the essential point of the operation. It is now the consensus of opinion that the first step of the operation should be the resection of the middle third of the clavicle as a preliminary step to the tying of the subclavian artery and vein. It is essential to tie the latter as well as the artery, in order to prevent the ingress of air. According to the publication by Nasse of Bergmann's cases, the Berlin surgeon begins his operation with the typical ligation of the subclavian artery to the outer side of the anterior scalenus muscle. This is followed by division of the clavicle. The arm is then elevated and the subclavian vein tied. The brachial plexus is at once divided. Oehsner has called attention to the fact that this plexus ought to be divided with a sharp knife rather than with scissors, since the shock is thereby greatly lessened. The cutaneous incision must vary somewhat according to the degree to which the soft parts about the shoulder are involved. Bergmann makes an anterior incision, through the skin only, from the incision made for the division of the clavicle straight through the axilla to the lower angle of the scapula. The posterior incision is made over the dorsal aspect of the scapula from the resection line of the clavicle to the end of the anterior incision. The illustration will indicate the lines of incisions recommended by Treves.* That for the antero-inferior flap extends outward from the incision made for the division of the clavicle to the outer and lower border of the axilla, which it crosses directly from before backward, whence it passes downward to the lower tip of the scapula posteriorly. The posterior incision extends across the upper surface of the shoulder, from which it inclines over the scapula to its lower angle, as seen in the illustration. After the lifting of the cutaneous flaps, the muscles are divided and the small vessels tied as they are encountered. In one of Kern's cases, owing to the involvement of the parts about the acromion, an oval incision was made beginning three inches above the acromion, each limb passing in front of and behind the shoulder respectively, and meeting in front of the inferior angle of the scapula. In the cases of recovery, the wounds heal within the course of ten days or two weeks. In operations for malignant disease, the prognosis is far more favorable when it is done for myeloid sarcoma than for periosteal sarcoma. The prognosis is more favorable in those cases in which the soft parts about the shoulder are not involved. Thus in all the cases of Heddaens recurrence rapidly took place.

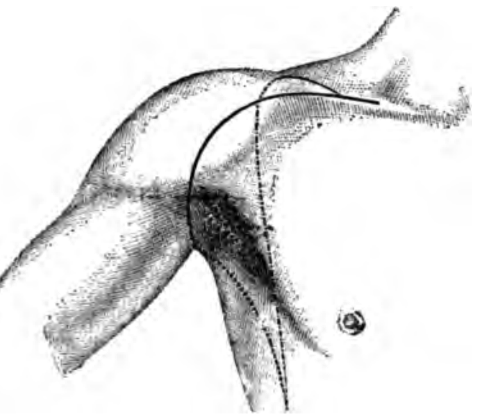

FIG. 156.—Interscapulo-Thoracic Amputation. (After Treves.)

* Treves: "Operative Surg.," vol. i., Fig. 98.

AMPUTATION OF THE TOES.—It is occasionally necessary to remove the toes in consequence of accident, disease, or deformity. While in cases of accident, it may occasionally be well to save a part of one of the smaller phalanges, it is generally best that the amputation be made at the metatarso-phalangeal joint. In amputations of the phalanges, a flap operation, like that for the fingers, must be made, care being taken, as in all amputations of the foot, that the cicatrix is placed on the dorsal aspect of the stump. In amputations of an entire toe, the incision should be commenced on the dorsal surface of the metatarsal bone, a little above the joint, but considerably above the web, and carried directly down an inch or more. It is then carried obliquely around the web on each side, in such a manner as to preserve as much of the soft parts as possible. This preservation of tissue is necessary for a sufficient covering for the large head of the metatarsal bone. When the operation is performed in this manner, the cicatrix is linear and entirely removed from pressure. No part of the metatarsal bone should be removed, lest the strength of the foot be deteriorated. Disarticulation of the great toe may be effected by the oval method just described, or by the formation of an internal flap. In the latter case, an incision is begun on the outer side of the extensor tendon, just below the joint, and carried longitudinally to the head of the first phalanx. From its lower end an incision is carried transversely around the inner side, to the flexor tendon, along the outer side of which it is continued backward to the plantar fold, whence it is again given a transverse direction around the outer side of the toe until it meets the first incision near its centre (Stimson). The rectangular flap thus marked out is dissected up, the tendons are divided, and disarticulation is effected. Although it is sometimes recommended, the head of the first metatarsal bone should never be removed unless it is implicated in the lesion, since it forms one of the most important points of support in the foot.

Amputation of all the toes at the metatarso-phalangeal joints may be made by carrying a curved incision along the groove between the base of the toes and sole of the foot from one margin of the latter to the other. The toes being forcibly flexed, a similar incision is made along the dorsum, which joins the ends of the plantar wound. The semilunar flaps thus formed are dissected back as far as the metatarso-phalangeal joints, when disarticulation of the individual toes can be made. It certainly cannot be often that a formal operation of this nature is called into requisition.

AMPUTATION THROUGH THE METATARSUS.—In consequence of injury or disease it not unfrequently becomes necessary to remove a part or all of the metatarsal bones. In amputations through individual bones of the metatarsus, conservatism must be particularly insisted upon, since, except in that of the great toe, the complete removal of a metatarsal bone cannot be accomplished without opening the large synovial sac which separates it from the first row of the tarsus. For amputations through the second, third, and fourth metatarsal bones, the longitudinal incision necessary for disarticulation at the metatarso-phalangeal joint must be carried upward for a distance varying according to the extent of bone to be removed. A short transverse incision is then made to facilitate the separation of the soft parts and the use of either chain-saw or bone-cutting forceps. When the bone has been divided, its distal end is drawn from the wound with a pair of stout forceps, and the operation is completed by severing the soft parts on the plantar surface of the foot with short strokes of the scalpel. The removal of the first and fifth metatarsal bones can be accomplished by the oval method or by internal and external flaps respectively. The oval method, where it is practicable, is doubtless preferable, since it yields a smaller wound and a cicatrix protected from pressure. The incisions for the oval amputation of the great toe with its meta-

tarsal bone are well shown in Fig. 157. On account of the great width of the base of the latter bone, a short

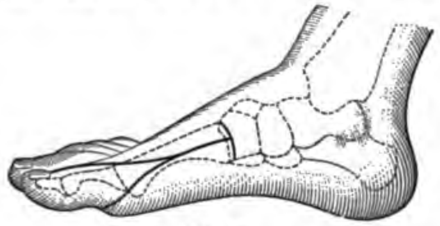

FIG. 157.

transverse incision facilitates the liberation of the flaps. In disarticulations of the fifth metatarsal bone the oblique line of its articulation with the cuboid bone should be borne in mind. When the first or fifth metatarsal bone is amputated in its continuity, the section should be made obliquely to avoid undue prominence of the stump.

FIG. 158.

Amputation in the continuity of all the metatarsal bones is not very infrequently called for, in consequence of injury or gangrene following frost-bite. When it can be resorted to, it is preferable to amputation through the tarso-metatarsal articulation. The operation is commenced with a curved incision carried along the anterior furrow of the sole of the foot, from border to border, and the semilunar flap thus outlined is reflected to the line where section of the bones is to be made. A smaller semilunar flap is then shaped from the dorsal surface of the foot. The interosseous soft parts are then divided transversely with a narrow knife, and retracted by means of narrow strips of linen, when the bones are sufficiently exposed for the application of the saw (Fig. 158). The appearance of the wound resulting from this operation is well shown in Fig. 159.

FIG. 159.

In this age of conservatism in surgery, in which "the least sacrifice of parts" is the leading tenet of surgical creed and practice, every half-inch of the foot that can be saved to the economy is properly considered of incalculable value. It is for this reason that, whereas before the times of Hey, Cho-

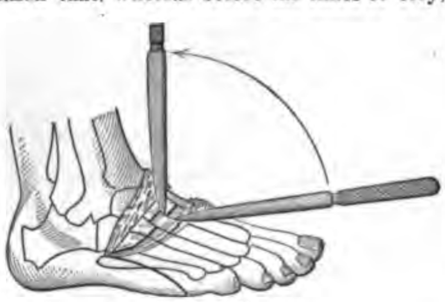

FIG. 160.

part, and Lisfranc, amputations of the foot above the ankle were made comparatively often, they have of late been largely replaced by partial amputations through the different articulations which it contains. The partial amputations which will be considered are the tarso-metatarsal, the medio-tarsal, the subastragaloid, and their modifications.

FIG. 161.

TARSO-METATARSAL AMPUTATION.—A glance at Fig. 161 shows the difficulty which the surgeon must contend with in this amputation of the foot. It is the firm impaction of the base of the second metatarsal bone between the internal and external cuneiform bones. In 1797, Mr. Hey, of Leeds, overcame this difficulty by disarticulating the outer metatarsal bones, and dividing the prominent internal cuneiform with a saw. Surgeons after him have generally adopted the plan of separating the outer three and the internal metatarsal bones at their articulations, and dividing the base of the second metatarsal below its articulation with the middle cuneiform. When disarticulation of all the metatarsal bones is effected the operation is known at Lisfranc's (1815).

FIG. 162.

Lisfranc's amputation of the foot is made as follows: The joint between the cuboid and prominent base of the fifth metatarsal bone having been marked on the outer side of the foot, and that between the first metatarsal and internal cuneiform (about one inch and a half below the tuberosity of the scaphoid) on the inner side, a large semilunar incision is made between them on the sole of the foot, the convexity of which should pass over the heads of the metatarsal bones. The plantar flap thus outlined may then be dissected up to its base. The foot being then forcibly extended, a slightly convex dorsal incision is carried between the ends of the plantar flap (Fig. 161). The flaps being retracted and the foot forcibly extended, the operator opens the joint from the outer or inner side, according to whether the right or the left foot be the seat of the operation (Fig. 162). The articulation of the second metatarsal bone (Fig. 161), which is less than half an inch above the general level of the joints, must then be opened by a transverse cut, the lateral attachments of the bone to the cuneiform being severed with the point of the knife

FIG. 163.

by longitudinal incisions (Fig. 160). When all the joints are widely opened by this process, the remaining ligaments at the side and sole of the foot, and the soft parts still undivided, are severed. As the operation is generally performed, the plantar flap is merely outlined by an incision through the skin in the first step of the operation, the

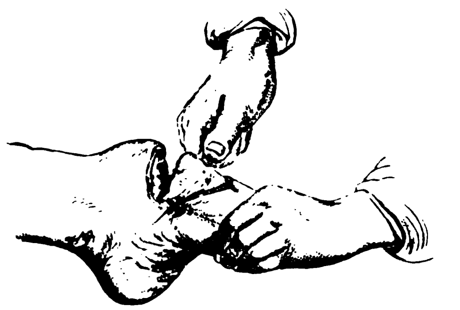

FIG. 164.

flap being cut from within outward after disarticulation has been effected. The vessels usually requiring ligation are the dorsal artery of the great toe, the metatarsal branches, and the plantar arteries. When the parts are brought together by suture, the stump should be placed in a posterior splint, to overcome the contraction of the powerful muscles of the calf of the leg. In Hey's amputation, the external incisions are identical with those necessary for the Lisfranc operation. The cicatrix resulting from either of these procedures is far removed from pressure, and the stump, on account of its length, is one admirably fitted for use.

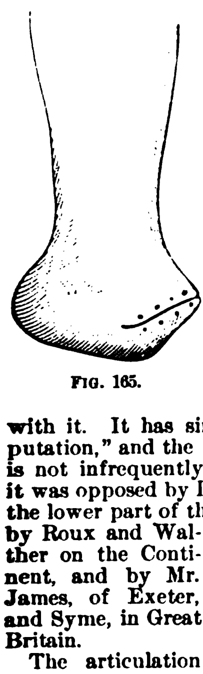

FIG. 165.

MEDIO-TARSAL AMPUTATION.—Although Garengeot and Heister mentioned the practicability of amputation between the rows of the tarsal bones, the operation was first performed by Du Vivier, of Rochefort, in 1781. In 1791 Chopart repeated the operation a number of times, and published his experience with it. It has since been known as "Chopart's amputation," and the joint between the rows of the tarsus is not infrequently designated by his name. Although it was opposed by Larrey, who preferred to amputate in the lower part of the leg, the operation was popularized by Roux and Walther on the Continent, and by Mr. James, of Exeter, and Syme, in Great Britain.

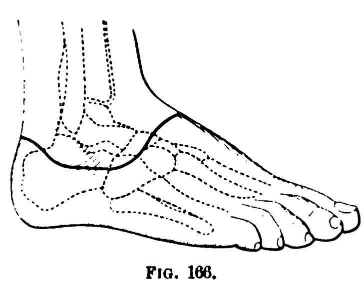

FIG. 166.

The articulation between the scaphoid and the head of the astragalus, and that between the cuboid and os calcis are respectively placed one-half inch above the tuberosity of the scaphoid on the inner border, and one inch or more above the prominence of the fifth metatarsal bone upon the outer border of the foot. These two points being fixed, a curved incision, extending to within an inch or less of the heads of the metatarsal bones, is carried across the sole of the foot, and connects them. The foot being then forcibly extended, a curvilinear incision, with convexity below, is carried between the same points across the dorsal surface. The small dorsal cutaneous flap thus outlined is retracted, and by one stroke of the knife the tendons are divided and the joint widely opened. The point of the knife then divides the lateral and plantar ligaments, which are put on the stretch by forcible extension until the articular surfaces of the scaphoid and cuboid bones are completely liberated. By inserting the knife behind these bones, the plantar flap is completed by cutting from within outward (Fig. 164). The vessels requiring ligation are the dorsal and two plantar arteries, and occasionally a few muscular twigs. The appearance of the stump after the completion of Chopart's amputation is well shown in Fig. 165, from Esmarch.

FIG. 167.

The only difficulty at times encountered in this operation is in the opening of the joint *in front of* instead of *behind* the scaphoid bone. The error is readily recognized through the presence of three articular facets on the anterior surface of the scaphoid bone, and can easily be corrected if it be desired, or the operation may be completed by dividing the cuboid bone with a saw on a line with the anterior surface of the scaphoid. In this manner the operator would be practising Forbes' modification of the medio-tarsal amputation, a modification also mentioned by Mr. Hancock and Professor Agnew.

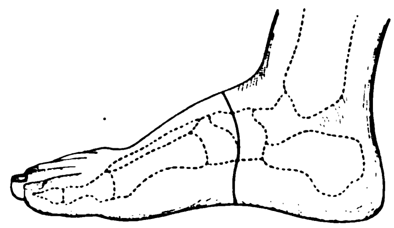

FIG. 168.

After Chopart's amputation, the gastrocnemius and soleus having exclusive control of the stump, there is a marked tendency toward its hyperextension. This may assume such a degree that the cicatrix itself will be pressed upon in locomotion. This objection to the operation is best overcome by bandaging the leg from above downward, and keeping the limb flexed. In extreme cases the difficulty is easily remedied by division of the tendo Achillis, and forced flexion of the stump.

SUBASTRAGALOID AMPUTATION.—Although, according to Velpeau, this operation was made by De Lignerolles and by Textor, it was first given prominence by Malgaigne, in 1846. In this amputation all the bones of the foot, except the astragalus, are removed. The operation is commenced by an incision, which, beginning behind and immediately above the great tuberosity of the os calcis, at once divides the tendo Achillis. The incision is then carried in a wide curve on the outer surface of the os calcis below the external malleolus (Fig. 166, Malgaigne). Thence it is continued over the middle of the cuboid and anterior margin of the scaphoid, across the dorsum of the foot (Fig. 167), and over its internal border to the centre of the sole (Figs. 168 and 169). From this point the incision is turned at a right angle and continued directly back till it meets the beginning of the incision at the inner border of the tendo Achillis (Esmarch). The short internal and long interno-plantar flaps thus formed are dissected up until the lateral surfaces of the os calcis are exposed, when disarticulation of the anterior part of the foot is effected in the medio-tarsal joint. The

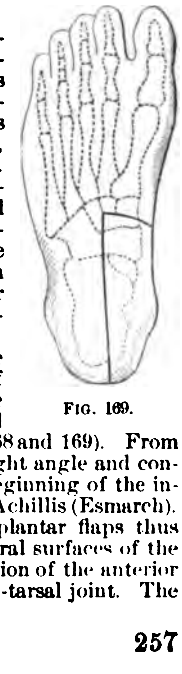

FIG. 169.

anterior end of the os calcis being then seized with a lion-jawed forceps, and rotated from side to side, the operation is completed by dividing the external lateral and interosseous ligaments. The appearance of the stump after this operation is shown in Fig. 170 (Esmarch). The marked irregularities of the inferior surface of the astragalus do not interfere with its usefulness in locomotion. In a case of gangrene in a deformed limb, Linhart performed the subastragaloid amputation, and was enabled two years later to examine the stump. The astragalus, which had maintained a perpendicular position before, and even at the time of amputation, had been forced into its normal horizontal position by the act of walking.

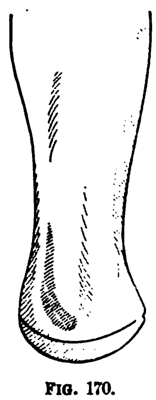

FIG. 170.

A number of modifications of the subastragaloid amputations, both in the direction of the incisions and in the preservation of parts of the os calcis, have been devised. In the operation of Mr. Hancock, a large plantar flap is reflected as far back as the tuberosities of the calcaneum, and a short dorsal flap is formed by a transverse incision across the foot on a level with the anterior margin of the astragalus. By the use of a saw, the plantar flap being retracted, a perpendicular section of the os calcis is then made in front of the tuberosities. Disarticulation of the foot, with the anterior portion of the os calcis, in the medio-tarsal joint is next effected, and the operation completed by making a transverse section of the astragalus. When the flaps are approximated the divided surfaces of the latter bone and os calcis are brought into apposition. The operation of Mr. Hancock, although as ingenious as that of Pirogoff, is much more difficult of execution, and time will probably show that the results obtained from it are far less valuable. In Tripier's operation the incision is made in the form of an oval, the apex of which is on the outer side of the foot, just beneath the external malleolus, while the sides pass forward and inward over the back and sole of the foot, and meet at its inner border. After disarticulation in the medio-tarsal joint, a transverse section of the os calcis completes the operation.

Partial amputations of the foot, at least in civil practice, are not attended with great mortality. Of 152 cases of Chopart's amputation examined by Hancock, only 11 terminated fatally, 7 per cent; the fatality following this operation in France has been much greater, 14 out of 38 cases recorded by Larger (36.8 per cent.) having died (Ashhurst). Of 22 cases of the subastragaloid amputation, 20 recovered.

Of 123 partial amputations of the foot, made during the late rebellion, in which the result was determined, 18 were unsuccessful, the mortality being 15 per cent. Of these partial amputations there were 83 of the medio-tarsals, with 11 deaths; 23 Lisfranc operations with 1 death, and 17 Hey's amputations with 6 deaths. Of 16 amputations of the foot at the Cincinnati Hospital, 1 died. The mortality according to Erdman's tables is 7.8 per cent. According to Page's tables the mortality is 3.8 per cent. for traumatic and 1.6 per cent. for pathological cases. In making a partial amputation, it must be remembered that the value of the stump for locomotion is proportionate to the length of foot maintained. Manufacturers of artificial limbs maintain that conservatism is out of place here, and that amputation several inches above the ankle should be given preference over partial amputations in front of or at the ankle.

FIG. 171.

AMPUTATION AT THE ANKLE.—Historically associated with this operation is the name of Syme, of Edinburgh, who, in 1842, devised and practised a method by which a shapely and useful stump could be obtained after removal of the entire foot. Disarticulation at the ankle had been performed during the last and early part of this century. It was performed by Sédillier, Rossi, and Baudens, and recommended by Brasdor and Sabatier. But the circular operation of the latter and the dorsal flap method of Baudens yielded alike unsatisfactory results, and the operation was, therefore, discarded for amputation in the lower part of the leg. Lateral flaps taken from below the malleoli, as suggested by Velpeau, also failed to form a sufficient cushion for the end of the tibia. This great desideratum in amputation at the ankle is squarely met by the operation of Syme, since its principal feature is the retention of the integument of the heel, which is accustomed to pressure, to form the end of the stump. The operation is made in the following manner: The foot being held at a right angle to the body, the malleoli are fixed by the thumb and fingers of the left hand, the heel resting between them. A *perpendicular* incision touching the bone is then made across the sole of the foot from the tip of one malleolus to that of the other* (Fig. 171). The posterior lip of the wound is then seized with the left hand, and the soft parts covering the calcaneum are separated from it by short strokes of the knife, which must be kept close against the bone to prevent perforation of the integument and damage to the plantar vessels. When, by this process of dissection, the tuberosities of the os calcis have been fairly exposed, a transverse incision joining the two extremities of the first is carried across the instep (Fig. 171). The ankle joint being thus opened from in front, the knife is carried down on each side of the astragalus until the lateral ligaments are divided, when complete disarticulation is effected. By forcibly depressing the foot the tendo Achillis should then be divided from before backward, when by a few strokes of the knife the foot can be removed (Fig. 172, Esmarch). Lastly, the knife is drawn around the extremities of the tibia and fibula, so as to expose them sufficiently for being grasped in the hand and removed by the saw. "After the vessels have been tied, and before the edges of the wound are stitched together, an opening should be made through the posterior part of the flap where it is thinnest, to afford a dependent drain for the matter."

FIG. 172.

The appearance of the wound after Syme's amputa-

* Recent writers justly observe that the incision on the inner side should end at least one-half inch *below* the malleolus.

tion is well shown in Fig. 173. It will be seen that the heel flap presents the form of a cup, which must be flattened by pressure against the bones of the leg. While there is danger, therefore, of making the flap too short, there is likewise a danger in making it too long, since a pouch would be formed for the retention of inflammatory products.

The favorable results which follow Syme's amputation in civil practice are shown by the statistics of Hancock and Spence, who, among 316 operations, found only 25 deaths (7 per cent.). In military practice the results are far less favorable. Of 159 amputations made at the ankle during the Civil War, and in which the result was determined, 40 terminated fatally (25.1 per cent.).


FIG. 173.

Pirogoff's Amputation.—On the principle that by preserving the posterior portion of the calcaneum the natural length of the limb could almost be preserved, Pirogoff, during the Crimean war, devised the osteoplastic operation that bears his name. It differs from the operation of Syme in preserving a portion of the os calcis, in the expectation that it will unite firmly to the divided end of the tibia. The incisions for this amputation are identical with those made in Syme's operation. After opening the joint from in front, the foot is depressed until the posterior extremity of the astragalus is exposed, when a saw is introduced behind this, and the os calcis divided exactly on a level with the incision in the sole of the foot (Figs. 174 and 175, Esmarch). Both malleoli and a thin section of the tibia and fibula are removed, as in Syme's operation. It is generally advisable to divide the tendo Achillis and at the same time to perforate the skin for the passage of a drainage tube. The appearance


FIG. 174.

of the stump after a successful Pirogoff amputation is well shown in Fig. 176, taken from a man who died three years after the operation was made by Linhart.

A number of modifications of Pirogoff's amputation have been devised. Ferguson and Agnew have wedged the end of the os calcis into the interval between the malleoli, and have obtained good results. Different methods of dividing the bone have been devised by Sédillot, Günther, Le Fort, and Bruns, to remove the pressure from the thin part of the integument on the back of the heel, which must bear it after the Pirogoff amputation, and to keep the retained part of the os calcis in its natural position. Sédillot and Günther, therefore, advised that an oblique section (from above downward and forward) of the calcaneum, tibia, and fibula be made. Le Fort (Fig. 175) advised a transverse section of the bone, by which the stump obtains a very broad base. Bruns has modified the operation of Le Fort by sawing the os calcis in such a manner as to make the upper surface of the retained part concave, the concavity thus formed receiving the convex section of the tibia and fibula.


FIG. 175.

A further modification of Syme's amputation is that of Guyon. It is an amputation above the malleoli. The operation is begun with an elliptical incision beginning one inch above the lower edge of the tibia in front, and, passing obliquely in front of the ankle, crosses the heel below the attachment of the tendo Achillis. The posterior portion of the flap is dissected from the heel and the tendon divided close to its insertion. The an-

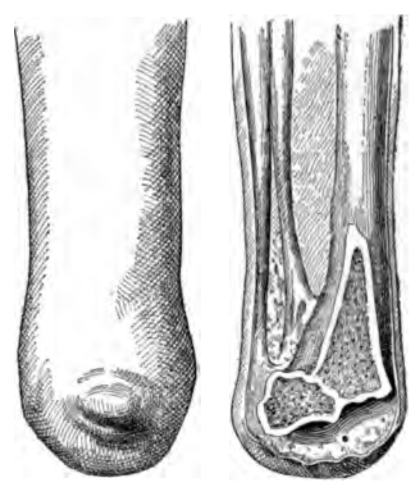
FIG. 176.

terior extensor tendons are divided transversely as high as possible. After the malleoli are exposed the fibula and the tibia are divided just above them. The heel end of the flap is then brought forward to cover them. The suture line is safe from pressure.

A comparison of the merits of Syme's amputation and its osteoplastic modification shows that a cure follows more rapidly after the latter than after the former, although the mortality of Pirogoff's amputation in military practice is 27.7 per cent., against 21.4 per cent. following that of Syme. Of 147 cases of Pirogoff's amputation collected by Hancock, Gross, and Pasquier, only 14 proved fatal, and Volkmann has performed the operation 34 times without a death. Considering the number of reamputations after Syme's and Pirogoff's operations, the latter would seem to be the more successful. Of 83 cases

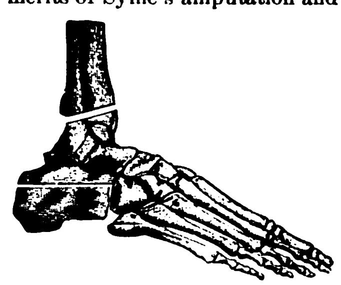
FIG. 177.

of Syme's amputation, 20, or 24 per cent., submitted to reamputation; of 49 Pirogoff's operations, 8, or 16.3 per cent., were subjected to reamputation.

In cases of caries involving all the bones of the tarsus, preference should be given to the Syme operation, since disease is not unlikely to develop in the retained segment of the calcaneum. In traumatic cases, the greater ease with which it is made and the length of limb which follows it should incline the operator to choose the operation of Pirogoff. That necrosis often follows the latter operation is emphatically denied by its originator, who had never witnessed it in over sixty cases in which he had performed it.

AMPUTATION OF THE LEG.—An amputation may be performed in any part of the leg, according to the nature and seat of disease or injury. When the surgeon can select the seat of operation, the amputation should be made two or three inches above the malleoli, on account of the greater safety of the operation in this locality and the greater power to be exerted over an artificial limb. In all amputations of the leg, the fibula should be divided from half an inch to an inch above the saw line of the tibia, to prevent pressure against the outer wound margin. The operations which have hitherto been most frequently performed in amputations above the malleoli are the circular and that by lateral flaps. Unhappily, the anatomical construction of the part is such that after these operations the cicatrices are central and not infrequently adherent, and therefore unable to bear pressure. In this situation M. Guyon practises the elliptical method. According to Stimson, this operation promises well. "The incision is made in the form of an ellipse, whose lower end crosses the heel below the insertion of the tendo Achillis, and whose upper end is about an inch above the anterior articular edge of the tibia. Beginning at the lower end and dividing the tendo Achillis at its insertion, and hugging the bone all the way, the operator dissects up the flap posteriorly as high as the upper end of the ellipse. The anterior muscles are then divided by transfixion, the bones sawn through, and the posterior tibial nerve resected. In this operation the sheath of the tendo Achillis is not opened, and the tendon itself serves afterward as a covering for the ends of the bones."

In amputations in the lower third of the leg in fleshy subjects, a long anterior flap containing the interosseous muscles may sometimes be used with advantage (Bell).

The rectangular operation of Teale may likewise be practised in this region, the long anterior flap being

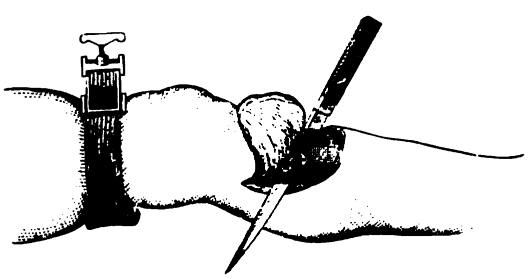

FIG. 178.

made from the soft part of its anterior aspect (Fig. 134, see above, Methods of Amputation). By this method the cicatrix, being placed posteriorly, is out of the way of pressure.

In the middle and upper thirds of the leg very many operators amputate by means of antero-posterior flaps after the following manner (for the left limb): The point of the knife being entered at the posterior edge of the tibia, an incision is carried downward along this for a distance of an inch and a half or two inches; then by a wide curve across the anterior surface of the leg it is continued to the posterior border of the fibula, up which it is carried until the level of its commencement on the opposite side is reached. The broad flap thus outlined is rapidly dissected up, the interosseous muscles being carefully severed from the underlying membrane. The posterior flap is then made by transfixion and cutting from within outward, and should be about three inches long (Fig. 178, Erichsen). The flaps being held out of the way, the catling is to be used for completing the division of the interosseous soft parts, care being taken that the arteries be divided transversely and only once. After division of the bones with a saw, the sharp anterior edge of the tibia should be removed obliquely with the saw or bone-cutting forceps.

For the upper portions of the leg the long posterior rectangular flap amputation advised by Henry Lee gives an excellent result. The incisions, similar to those of the Teale operation, involve only the skin, the long flap being made from the posterior, the short one from the anterior surface of the limb. With the long posterior flap only the superficial muscles of the calf are reflected, the remaining soft parts being divided by a circular incision. A good covering is likewise obtained in this region by an external flap, made either by transfixion (Sédillot), or by cutting from without inward (Langenbeck). In the former operation the knife is entered a little external to the crest of the tibia, and while the soft parts are drawn to the outer side with the left hand, it is made to graze the surface of the fibula and to perforate the posterior surface of the limb as far to the inner side of the fibula as possible. By cutting downward, close to the bones, a broad rounded flap, three to four inches long, is formed. The extremities of this flap are then united by a slightly convex incision across the antero-internal aspect of the limb. The remaining soft parts being then divided by circular incision, the operation is completed in the ordinary way. In Langenbeck's operation, the internal incision is semicircular, and the external flap being cut from without presents a smoother surface and a more perfect outline. The arteries requiring ligation after amputation of the leg are the tibials, peroneal, and a varying number of muscular branches.

Subperiosteal Amputation.—When amputations of the leg are unsatisfactory, it is chiefly because of two things, namely, gangrene of the flaps, and the tendency of the stump to become conical, or, at any rate, to be unable to bear pressure. It is for this reason that Bruns devised his subperiosteal amputation, of which he reported seventeen cases in 1893. According to a recent report,* this operation was performed in eighty-four cases without a death. In only three cases was there gangrene of the flaps, and in only two cases was a second amputation necessary. The operation is performed as follows: The skin being well retracted by an assistant, a circular incision involving all the soft parts is carried down to the bone. The two perpendicular incisions, from two to three inches in length, are then made, one along the inner border of the tibia, the other between the muscles over the fibula. Both incisions are carried to the bone through the periosteum. Through these incisions all the soft parts, including the periosteum, are raised from the bone. After the soft parts are well retracted the bones are divided in the usual way. After the amputation has been completed, there remain an anterior and a posterior flap of periosteum, muscles, and skin. The muscles are united separately by buried suture. When the amputation is done in the upper portion of the leg, the circular incision through the skin is made at a higher level than that through the muscles.

Osteoplastic Amputations of the Leg.—In 1892, Bier,† of Kiel, first described a method of securing a weight-bearing stump, which, in patients who are unable to purchase an artificial limb, secures for them a stump which will bear the body weight. The operation consists of the usual circular amputation. Thereupon follows, through an oval window cut into the soft parts, a cuneiform excision of part of the fibula. When the resection surfaces

* Hahn: "Beiträge zur klinischen Chirurgie," vol. xxii., part ii.
† Deutsche Zeitsch. f. Chir., vol. xxxiv., p. 436.

of the tibia are brought into apposition a kind of artificial foot projects anteriorly. The posterior surface of the tibia covered by the soft parts of the calf bear pressure. Bier has operated in many cases with uniformly good results. Some German surgeons think that this should be the normal procedure. A number of minor modifications of the original method have been made. When there is any possibility that the patient can secure an artificial limb, the operation has nothing to commend it. Figures 179 to 182 will illustrate the method of amputation and the result.

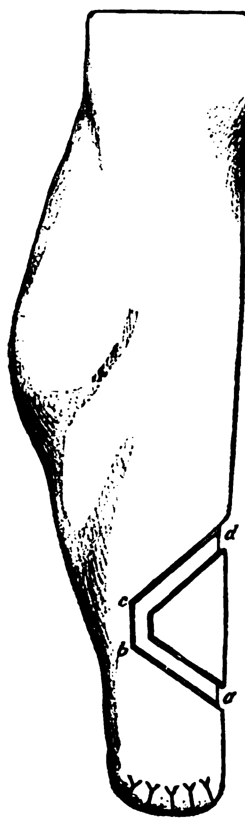

FIG. 179.

FIG. 180.

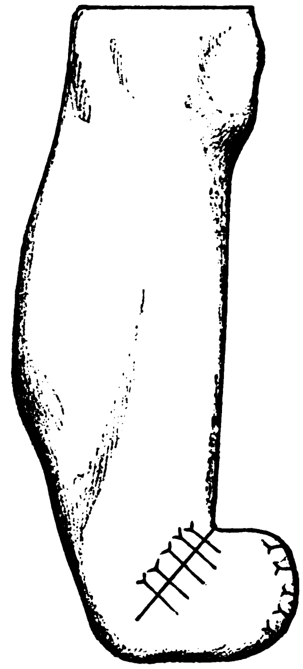

FIG. 181.

FIG. 182.

FIGS. 179 TO 182.—Osteoplastic Amputation, After the Method of Bier. (Langenbeck's Arch. f. Chir., vol. xlvi.)

Since good results follow all the different methods of operation in the middle and upper portions of the leg, the surgeon should be guided in his choice solely by the desire to sacrifice as little of the limb as possible. An exception should probably be made in the upper portion of the upper third, where it is better to amputate at the knee than to save only the portion of the tibia above its tubercle.

The mortality following amputation of the leg, as has already been seen, is largely determined by the conditions necessitating it. According to Chadwick, the mortality of pathological amputations is 16 per cent.; that of amputations for trauma nearly 37 per cent. The general mortality of the operation at Guy's Hospital for a period of thirty years was 35 per cent.; that for traumatic amputations being 55 per cent., against 15 per cent. following those for disease. Volkmann, who employs a long anterior and short posterior flap, performed the operation in 54 cases with only 4 deaths (7 per cent.), of which there were 14 traumatic cases with only 2 deaths (14 per cent.). Of 46 amputations in the leg made by Bruns, 7 succumbed (16 per cent.). The fatality following amputations of the leg in military practice is well shown by the statistics of Otis. Of 5,314 amputations in which the result was determined, 1,758 terminated fatally, the mortality being 32.9 per cent. From statistics obtained during the late War of the Rebellion, it appears that amputation of the leg is attended with least danger when performed in the middle third. The fatality of operations in the upper third was 27 per cent., in the middle third, 20.6 per cent., and in the lower third, 27.6 per cent. The mortality of amputations of the leg has been greatly reduced. Of 81 amputations of the leg 5, or 6.2 per cent., died. In the New York hospitals the mortality is 12 per cent. In the Newcastle-on-Tyne Infirmary it is nearly 7 per cent.

Amputation at the Knee.—According to Sabatier, this operation was first performed by Fabricius Hildanus in 1581, in a case of gunshot injury. Although advocated by Guillemeau (1612) in preference to higher amputation, there is no record of a repetition of the operation until 1764, when it was successfully performed by Hoin, of Dijon, for traumatic gangrene. Brasdor and J. L. Petit advised the operation, the latter having twice witnessed it. In 1830, Velpeau attempted with success firmly to establish the operation by citing a number of successful cases. The operation was first performed in this country by Nathan Smith, of New Haven, in 1824, since which time it has gradually grown in popularity. Fergusson and Legouest for a long time questioned the advisability of the operation, preferring amputation in the lower portion of the thigh. The reasons which prevailed to give this operation recognition are the greater length of the stump and its ability to bear pressure, the smaller probability of pyæmia, the medullary canal remaining unopened, and, most important of all, the smaller mortality which follows this operation, at least in civil practice, as compared with amputations of the thigh.

Amputation at the knee may be practised by either the

circular, the flap, or the oval method. In all methods of amputation it is best, if possible, to preserve the semilunar cartilages. Thereby the fascial attachments are maintained intact, and the tendency to retraction of the flaps

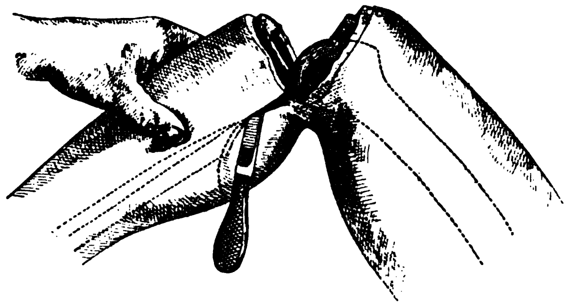

FIG. 183.

is greatly reduced. The circular operation recommended by Velpeau, Sanson, and Malgaigne, made by an incision two or three inches below the patella and the reflection of a cuff, is difficult of execution, and should be resorted to only when an insufficiency of tissue prevents the adoption of one of the other methods. The oval method has been practised by Baudens and Sédillot, the former preferring the integument from the anterior portion of the leg, the latter that from the posterior portion, as a covering for the end of the femur. The operation of Baudens is performed as follows: An oval incision is carried around the leg, crossing its anterior surface five finger

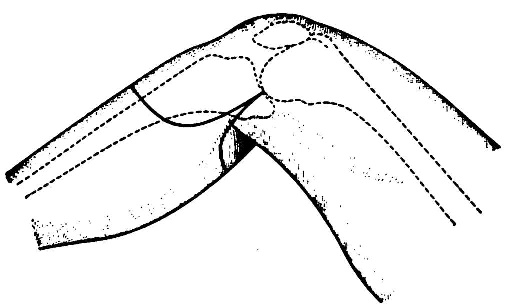

FIG. 184.

breadths below the end of the patella, and its posterior surface three finger-breadths higher than in front. The anterior and lateral portions of the oval are then reflected until the ligamentum patellæ is fairly exposed. This is then divided transversely, the capsule is fairly opened, and the lateral and crucial ligaments divided. In this, as in all amputations of the knee, the latter structures should be divided with the point of the knife, and from behind forward, to prevent injury of the popliteal vessels. When disarticulation has been effected, the soft parts on the posterior aspect of the limb are divided with one sweep of the knife. This operation is, doubtless, preferable to Sédillot's method, according to which the lower part of the oval is placed behind.

In amputating at the knee, a long flap may be taken from the anterior or posterior surface of the leg. The latter method, that of Hoin (Fig. 183), can be most readily executed, but is objectionable on account of the excess of muscular tissue in the flap, and the difficulty of establishing thorough drainage. Lateral flaps have been advised by Rossi and Stephen Smith. The operation which is generally performed, however, is that by one long anterior and one short posterior flap. It is readily performed, and leaves a wound that is easily drained, and a stump in which the cicatrix is protected from pressure.

Operation.—The leg being raised, a semilunar flap, three to four inches long, is outlined from the calf, the incision beginning a little below the middle of the lateral border of the condyles. This flap is dissected up as far as its base. The leg being then flexed, an anterior flap, four to five inches long, is outlined on the anterior surface of the leg from the ends of the posterior incision (Fig. 184, Esmarch). The anterior flap is then raised from its attachments until the ligamentum patellæ is encountered and transversely divided. The capsule is then extensively incised laterally, and the anterior flap, including the patella, reflected (Fig. 185). Disarticulation and division of the soft parts on the posterior aspect of the limb are then effected in the manner already described. This operation is preferable to forming the posterior flap without the guidance of a cutaneous incision. The vessels requiring ligation are the popliteal artery and vein, which should be carefully separated and tied individually. A number of smaller arteries, sural and muscular, will also require ligation in the posterior portion of the wound.

FIG. 185.

A number of operators (Billroth among them) advise the removal of the patella, lest inflammatory products accumulate in the pouch above it. This procedure is generally held to be superfluous, since the upper part of the wound can readily be drained without it, and the removal of the patella endangers the vitality of the long flap. It is always advisable, to insure drainage, to divide the lateral attachments of the synovial membrane to the femoral condyles, by which means the retention of inflammatory products in the pouch alluded to can be avoided.

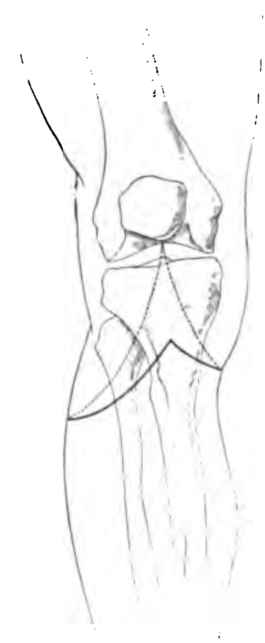

FIG. 186.

In 1870 Stephen Smith* described an amputation by "lateral hooded flap." It leaves an admirable stump, the cicatrix being placed behind and between the condyles. The writer gives it the preference over other amputations through or immediately above the knee.

Fig. 186 illustrates the incisions of this amputation and the method of forming the flaps. The incision begins an inch below the tuberosity of the tibia and passes over the outer side of the leg and is carried in a gentle curve to the middle of the posterior surface. Here it ends opposite to the interarticular line. A similar but longer flap is outlined on the inner side. The flaps are then dissected up and are made to include everything down to the bone. While the flaps are being formed the limb must be maintained in extension. The disarticulation completes

* Amer. Journ. of the Med. Sciences, 1870, vol. lxix., p. 33.

the operation, the semilunar cartilages being retained in the stump.

In the last forty years a number of modifications of the operations just described have been introduced. They all have the feature in common that a portion of, or the entire condyles of the femur are to be removed. In 1845 Syme advised amputation through the condyles, making a large posterior musculo-tegumentary flap. In 1846 Mr. Carden first performed the operation which has since borne his name, and has become deservedly popular. The operation consists in the formation of a long anterior flap, which, like a hood, falls easily over the divided end of the bone. The incision, similar to that made for amputation at the knee, extends no farther down than the tubercle of the tibia. The anterior flap being reflected, the joint is opened *above* the patella, which is not included in the flap. After disarticulation has been effected, the soft parts of the posterior aspect of the limb are severed by a single stroke of the knife, and the saw is applied through the bases of the condyles. For the better coaptation of the cutaneous margins of the wound Lister has advised the formation of a short posterior tegumentary flap. Mr. Carden has recorded 30 operations, with only 5 deaths from this method. Of 26 Carden amputations made by Volkmann, 3 terminated fatally.

In 1857, Gritti, of Milan, devised an osteoplastic operation by which the articular surface of the patella is removed and placed in apposition with the divided ends of the femoral condyles. The operation was first practised by Sawostytzki in 1862. In this operation, long anterior and short posterior rectangular flaps are formed. Paikrt and Linhart, after raising the anterior flap, amputate without first disarticulating. In 1870 Dr. William Stokes still further modified Gritti's operation by making an oval flap and dividing the femur at least half an inch above the antero-superior margin of the condyloid cartilage. Hence this amputation is generally known as the *supracondyloid* amputation, that of Carden being known as the *transcondyloid* operation. The relative merits of these various methods of amputation at the knee have been extensively investigated by American, English, and German writers. Edmund Andrews, of Chicago, shows that disarticulation at the knee and transcondyloid amputation present a like mortality (28 per cent.). Of Gritti's operation and Stokes' modification, Dr. R. F. Weir has collected 76 cases with 22 deaths. While time may show that the last-mentioned procedures may be of service in amputations for disease, sufficient evidence has been adduced by Zeiss, Beck, and Salzman, that, so far as military practice is concerned, the operation ought to be abandoned. From the more recent statistics quoted above for other amputations, the mortality of amputations at the knee in civil practice is 11 per cent., there being 7 deaths for 62 operations.

The mortality of amputations at the knee in civil practice appears from an examination of Table I. (see above). Of 187 amputations made for gunshot injury, in which the result was determined, 106 succumbed, the mortality being 56.6 per cent., and exceeding by 2.8 per cent. the fatality of amputations in the lower part of the femur.

AMPUTATION OF THE THIGH.—This operation may be called for in any part of the thigh. The central position of the femur, and its extensive muscular covering, sanction the application of any of the various methods of amputation in this part. The choice from among the different operations permits the surgeon at all times to save as much of the femur as possible. Until twenty years ago amputation of the thigh was generally performed by the transfixion method, by which an anterior and a posterior flap were formed. The rapidity and ease with which it could be performed were its chief commendations. The manner in which it is generally performed is the following: Grasping and raising the soft parts on the anterior aspect of the limb with his left hand, the operator introduces the knife at the side of the limb, at a point an inch or more below the level of the proposed section of the femur, and, carrying it across the anterior surface of the femur, transfixes and cuts out a broad flap equal in length to half the diameter of the limb (Fig. 187, Fergusson). The flap thus formed being retracted, the knife is again introduced into the wound behind the femur, and a posterior flap formed by cutting from within outward and downward through the soft parts. The flap thus made should be quite as long as

FIG. 187.

the anterior, since the greater retraction of the posterior muscles would otherwise reduce it to a size that would prevent the accurate coaptation of the cutaneous margins of the wound. In very fleshy subjects, all of the muscular tissue should not be included in the flaps thus made. When the flaps have been made they are retracted by an assistant, the bone is cleared of the still adherent soft parts by a circular sweep of the knife at the level where the saw is to be applied. In amputating by musculo-tegumentary flaps below the middle of the thigh, the anterior flap should be formed first; in amputations higher up it must be made last, in order that the femoral vessels may not be divided until the operation has been nearly completed. The vessels requiring ligation in amputations below the middle of the thigh are the femoral, anastomotic, and five or six muscular branches. To insure a smooth margin to the flaps, it is well first to outline them by an incision extending through the skin alone.

Amputation of the thigh by lateral musculo-tegumentary flaps, as recommended by Vermale, should not be resorted to, since, owing to the weight of the soft parts, the flaps are easily displaced, and the end of the bone is liable to protrude from the upper angle of the wound.

In the middle and upper portions of the thigh the very best results are unquestionably to be obtained by the modified circular method, the cutaneous flaps being made in front and behind, and the muscles divided by a circular incision. The admirable results which Volkmann and Bruns achieved from amputations of the thigh are largely attributable to their preference for this method. With a longer anterior and shorter posterior cutaneous flap, the wound obtains an excellent position for drainage (Fig. 188, Hueter), and the stump which is left is well suited for the application of an artificial limb. In the lower third of the thigh the operation may be made with only a single long anterior flap, which should extend as low as the upper margin of the patella, the integument on the posterior aspect of the limb being divided by a semicircular incision. The latter should be made at least half an inch below the margins of the anterior flap, to allow for the greater retraction of the

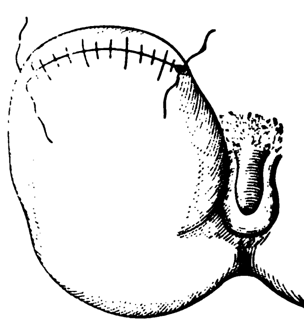

FIG. 188.

posterior lip of the wound (Fig. 189). In amputations near the hip or through the trochanters, no other operation than that by long anterior and short posterior flaps leaves a wound that is easily drained. When there is any question as to the vitality of the long anterior flap, it is an easy matter to include with it a varying thickness of the muscular tissue.

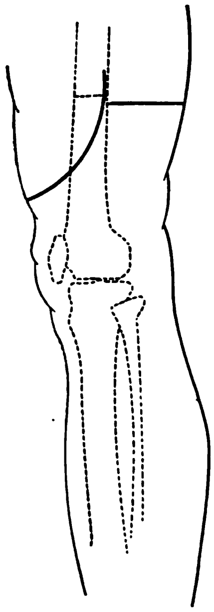

FIG. 189.

When an amputation of the thigh is demanded for senile or diabetic gangrene, it is essential that the flaps shall be short. The circular amputation, with short liberating lateral incisions and circular division of the muscles in different planes, without question gives the best results.

A study of Table I. shows that amputations of the thigh are associated with a mortality that is largely responsible for the high death rate attending major amputations in general. The fatality of this operation in civil practice increases as the trunk is approached.

According to Macleod and Legouest, this applies equally to amputations for gunshot injury.

According to the statistics of Otis, this view, which is generally entertained, must be modified. Of 768 amputations for gunshot injury, made in the upper third of the thigh, 53.8 per cent. died. Of the 1,866 amputations made in the middle third, 44.5 per cent. died. Of 2,901 operations in the lower third, 53.6 per cent. succumbed.

The general mortality attending the operation is represented by 6,229 cases, with 3,310 deaths, the mortality being 53.8 per cent.

By modern methods the mortality of amputations has been greatly reduced. From the sources above quoted, of 465 amputations of the thigh, 79, or 17 per cent., were fatal. Of 154 amputations for disease done at the Newcastle Infirmary, 10 died. Of 20 done at the Cincinnati Hospital, only 3 died.

AMPUTATION AT THE HIP.—The first idea of this operation, the most formidable of justifiable surgical procedures, appears to have originated with Morand and two of his pupils, Volker and Puthod, who practised it on the cadaver in 1738. A year later, Le Dran taught the operation in his practical courses, and presented a report on its feasibility to the French Academy. In 1740 Ravaton proposed to amputate at the hip joint on a patient, but was dissuaded therefrom by other surgeons in consultation. In 1756 and 1759 the Paris Academy offered a prize for the best treatise on the justifiability of the operation and the best method of performing it. Of forty-four contestants, thirty-four supported the operation, the prize being awarded to Barbette, who concisely mentioned the indications that made it necessary. That life could continue after loss of the lower extremities had been shown by the following case: "In 1748, there came to the hospital of Orleans, a lad fourteen years of age, who was the subject of ergotism. Gangrene of both lower extremities had supervened, extending on the right side to the hip joint, and on the left to the trochanter. The suppuration which was established almost separated the right thigh, the round ligament and great sciatic nerve alone holding it to the trunk. Lacroix, surgeon to the hospital, completed the separation of the member. This operation succeeded so well that four days later he also amputated the left thigh. There was neither hemorrhage nor pain, and the patient progressed well till the tenth day, when fever supervened, and death followed fifteen days after the first operation." In 1773 Perault removed the entire thigh in a case of traumatic gangrene "of several months' duration," in which a complete recovery ensued in eighteen months.

Although in 1774 and 1778 Kerr and Thomson made the first amputations at the hip through living tissues in cases of coxalgia, both operations terminated fatally, and the procedure was not again resorted to till the last decade of the past century. Amputation at the hip in reality owes its existence to the wars of the French Revolution. In 1794 the elder Blandin performed it thrice, with one recovery. During his different campaigns, Larrey repeated the operation seven times and gave it a standing among surgical procedures, although it is doubtful whether any of his cases recovered. In 1812 and 1815, Brownrigg and Guthrie, after repeated failures, were enabled to report successful amputations at the hip for gunshot injury. The first operation in this country was made in Kentucky in 1806, by Brashear, for compound fracture, and ended in recovery.

The most comprehensive statistics of the operation in question have been collected by Otis, Lüning, and Ashhurst. Over three-fourths of all the operations have been made since the introduction of anæsthesia, and fully two-thirds of the entire number were performed later than 1860. Up to 1875 Lüning was enabled to collect but 497 well-authenticated cases, while in 1881 Ashhurst was enabled to tabulate 633 operations, since which time over 100 cases have been added to the list.

The question of supreme moment in amputation at the hip joint is that which pertains to a complete, and yet safe method of controlling the circulation during the operation. Its importance becomes manifest from the fact that five per cent. of the patients operated on do not survive the operation, and that seventy per cent. of the deaths occur during the first five days (Lüning). To overcome this great and immediate danger of amputation at the hip, progress has been made in the direction of preserving the blood contained in the condemned part and by temporarily or permanently occluding the sources of its blood supply. By the use of the elastic bandage from the toes to the groin, and by keeping it in place during the operation (Erskine Mason), or, in cases of extensive suppuration of the extremity, by maintaining the latter in a vertical position for some minutes before the operation, a not inconsiderable amount of blood can be saved to the economy.

In 1860 Professor Pancoast first called attention to the practicability of compressing the aorta against the vertebral column by means of an abdominal tourniquet. A number of instruments have since been devised similar to that of Pancoast, by Lister, Skey, and Esmarch, and it is to one of these contrivances that most surgeons have recourse before proceeding to the operation proper. In the tourniquet of Esmarch, the aortic pad exerts its compression by means of an elastic band which is passed through its handle.

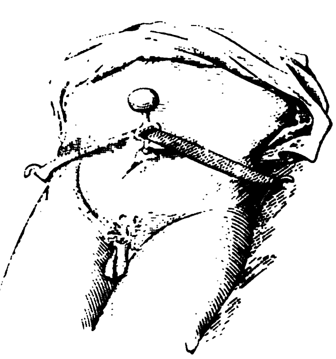

FIG. 190.

In the absence of a tourniquet, a pad can be improvised by firmly winding a long roller bandage around the middle of a stick, which should be about a foot long and of the thickness of the thumb. The pad thus formed being placed in position, is retained by five or six turns of an elastic bandage around the abdomen (Esmarch). Professor Spence resorts to a similar procedure. Whatever tourniquet be used, it should be applied while the patient is lying on the right side, the

pad being placed a little to the left of the umbilicus (Fig. 190, Esmarch). The operation should not be commenced until the operator has satisfied himself that the circulation in the lower extremities is completely controlled.

It having been held, but without sufficient clinical evidence, that prolonged compression of the abdominal aorta is injurious from damage to the branches of the solar plexus, and by interfering with respiration, compression of the common iliac artery through the rectum has been advised and practised.

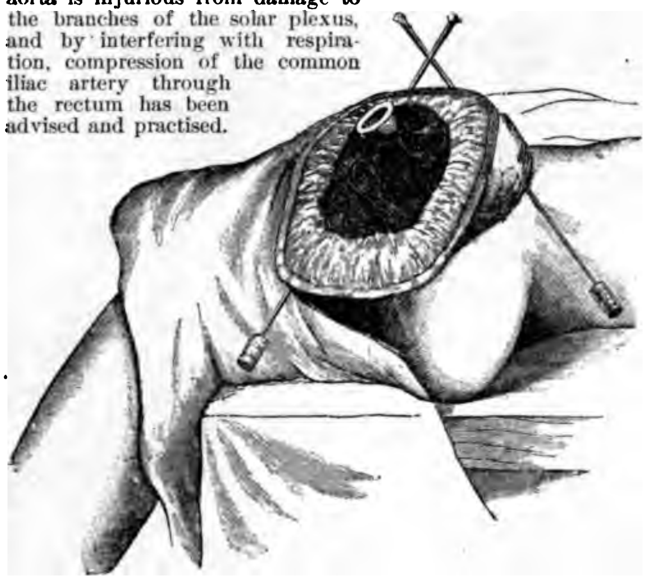

FIG. 191.

Woodbury, of Philadelphia, and Van Buren, of New York, proposed that this be accomplished by the hand of an assistant, while R. Davy, of London, devised for the same purpose a polished rod twenty inches long, and from one-half to three-fourths of an inch thick, surmounted at its extremity by an ivory enlargement, with which the artery is to be compressed against the brim of the pelvis. In one case in which Davy used the lever on the right iliac artery, death followed from a rent in the rectum. In 17 other cases in which he had resorted to its use an accident resulted. According to the originator of the "lever," this instrument has been used in 40 cases, in an almost equal proportion of amputations of the right and left side, and 65 per cent. of the cases recovered. Recently Davy* reported 10 cases with 8 recoveries.

In thin or emaciated subjects, the circulation can be controlled by digital compression of the aorta or external iliac artery, or both may be employed (Gross). It may likewise be effected by the use of a wide roller bandage placed over the external iliac and held in position by an elastic bandage. The latter should be about two yards in length, its centre being placed between the anus and tuberosity of the ischium; the anterior part of the bandage is brought above the crest of the ilium, the posterior portion crossing the sacro-sciatic notch and meeting the anterior above the iliac crest; both are firmly held in position by an assistant. This method of preventing hemorrhage from both anterior and posterior flaps has been resorted to in four cases by Jordan Lloyd, of Birmingham, three of which recovered.

With the introduction of better methods against hemorrhage, the use of the abdominal tourniquet, of Davy's lever, and of digital compression can no longer be advised.

In 1876 Trendelenburg, of Rostock, devised a steel rod fifteen inches long, one-fourth of an inch wide, and one-eighth of an inch thick, with a movable point attachment which is to be pushed through the soft parts in front of the joint, an inch above the level where transfixion is to be made with the knife. "The rod having been pushed through the soft parts, the point is removed and a rubber tube wound around the protruding ends of the rod in figure-of-8 turns. In this manner compression of all the soft parts in front of the joint is effected, and the flap can be made without loss of blood. After the vessels divided in the anterior flap have been ligated, the rod is introduced through the soft parts behind the joint in a similar manner before the posterior flap is made." Although tedious in its performance, this method of controlling hemorrhage is thoroughly practicable and promises good results. It has been successfully resorted to by Varrick in a case of traumatic amputation in a subject very anæmic from hemorrhage.

In 1890, Wyeth* described a bloodless amputation at the hip, which, while it appears to be an amplification of Trendelenburg's method, is exceedingly simple, and can be highly recommended for all amputations at the hip, save those rare cases in which the disease involves the trochanter. In these cases the transperitoneal ligation of the external, or, better still, of the common, iliac is to be preferred to the pins and constriction used by Trendelenburg and Wyeth. The accompanying diagrams (Figs. 191 and 192), inserted with Dr. Wyeth's permission, illustrate the method of the introduction of the pins.

The patient is placed with the hip well over the end of the table, and an Esmarch bandage is applied. With the bandage still in position, Dr. Wyeth's needles are inserted as follows: "Two steel mattress needles, three-sixteenths of an inch in diameter and a foot long, are used. The point of one is inserted an inch and a half below the anterior superior spine of the ilium and slightly to the inner side of this prominence, and is made to traverse the muscles and deep fascia, passing about half way between the great trochanter and the iliac spine, external to the neck of the femur and through the substance of the tensor vaginæ femoris, coming out just back of the trochanter. About four inches of the needle should be concealed by the tissues. The point of the second needle is entered an inch below the level of the crotch, internally to the saphenous opening, and, passing through the adductors, comes out about an inch and a half in front of the tuber ischii. No vessels are endangered by these needles. The points are protected by corks to prevent injuries to the operator's hands. A piece of strong white rubber tube, half an inch in diameter, and long enough when tightened in position to go five or six times around the thigh, is now wound very tightly around and

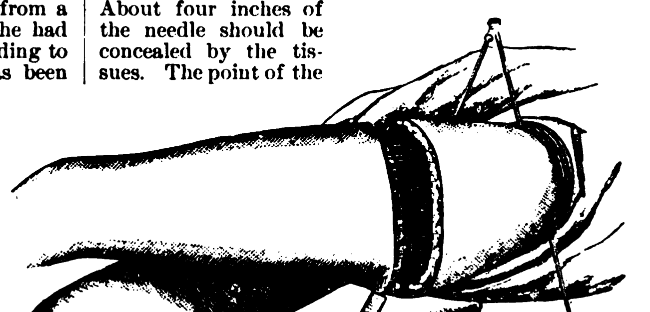

FIG. 192.

* London Lancet, 1892, i., p. 570.

* Wyeth: New York Med. Journ., 1890, ii., p. 528.

above the fixation needles and tied." The Esmarch bandage is then removed, and if the operation is to be completed according to Dr. Wyeth's plan, a circular incision is made, the skin flap is turned up, the muscles are divided at the lesser trochanter, and the bone is sawed through. All vessels are then tied. The remaining portion of the femur is then removed by division of the attachments of the muscles.

Methods.—Although a large number* of methods of amputation at the hip have been devised, only a few of

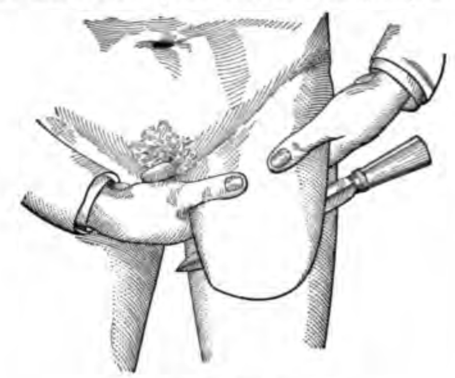

FIG. 193.

them are of practical value, and are, therefore, commonly employed. The methods which will be considered are, that by musculo-tegumentary flaps, that by cutaneous flaps and circular division of the remaining soft parts, and that by a high circular amputation with subsequent excision.

Musculo-tegumentary Flaps.—Amputation at the hip can be most quickly accomplished by means of antero-posterior muscular flaps, of which the anterior is made by transfixion, and the posterior by cutting from within outward. With able assistance the operation can easily be performed in less than twenty seconds. At least three assistants are required in this, as in all amputations of the hip. One of these is entrusted with the control of the circulation in the limb, the second follows the knife to grasp the flap before the artery is divided (Fig. 193, Hueter) and then to retract it, and the third takes charge of the condemned limb.

The patient's body having been brought to the foot of the table, the nates are made to project over its edge, and the scrotum and sound thigh are held out of the way. While the condemned limb is slightly flexed, the operator, standing on the left side, enters the point of an amputating knife, the blade of which is at least a foot long, midway between the anterior superior spinous process of the ilium and the trochanter major. It is carried deeply into the limb in a direction parallel to Poupart's ligament, across the anterior surface of the joint, which is thus opened, and made to issue on the inner surface of the thigh close to the perineum and just in front of the tuberosity of the ischium. Transfixion accomplished, a broad rounded flap, five to seven inches in length, is made by carrying the knife downward in front of the bone and cutting outward. This flap is at once reflected and held out of the way. By a transverse incision on the head of the bone the capsule is then widely opened, while the limb is forcibly abducted and everted. Hyperextension then causes the head of the bone to start from its socket with a "popping" noise when the ligamentum teres is cut. The knife being then introduced behind the head of the femur, the posterior portion of the capsule is divided and a posterior flap four inches in length is cut from within outward (Liston). When the operation is made on the right side, the knife is entered from the inner side just above the ischial tuberosity. When the posterior flap is cut from within

* According to Ashhurst there are forty-five.

outward, the cutaneous margin of the wound is generally irregular and not well suited for close coaptation with the anterior flap. It is advisable, therefore, particularly in robust limbs, either to outline this flap by an incision through the skin, or to cut it altogether from without inward (Fig. 194, Esmarch) (Manec). Indeed, both flaps may advantageously be cut in this manner (Guthrie).

The great advantage of the operation just described is in the rapidity with which it can be executed. Its disadvantages are in the excessively large wound which it leaves, the tendency to the retention of pus in the intermuscular spaces, and the great probability of excessive hemorrhage from the posterior flap.

A wound better suited for drainage is that made by lateral flaps. In this form of operation a semicircular incision is made, beginning at the tuberosity of the ischium, and terminating on the outer side of the femoral vessels in the centre of the groin. The incision crosses the outer surface of the thigh four or five inches below the trochanter. The flap thus outlined is then reflected over the latter and the joint opened. The inner flap is then made by cutting from within outward.

Tegumentary Flap Method.—This is an admirable method to overcome the superfluity of muscular tissue in the wound and the consequent tendency to purulent infection, and it is therefore preferred by a number of operators, among whom are Agnew and Volkmann. The operation is described by Agnew as follows: "The surgeon makes a semilunar incision in front of the limb, with its convexity downward, and, commencing midway between the anterior superior spinous process and the trochanter on the outside, descending the thigh in a longitudinal direction for five inches, then passing across the front of the limb in an oval course, adding thereby an inch to the length of the flap, and, last, ascending the inner border of the thigh, and terminating one inch below the ramus of the pubes. The integument is now rapidly dissected up from the deep fascia and entrusted to the fingers of an assistant."

The next step is to isolate the femoral vessels above the origin of the profunda, and to apply separately to

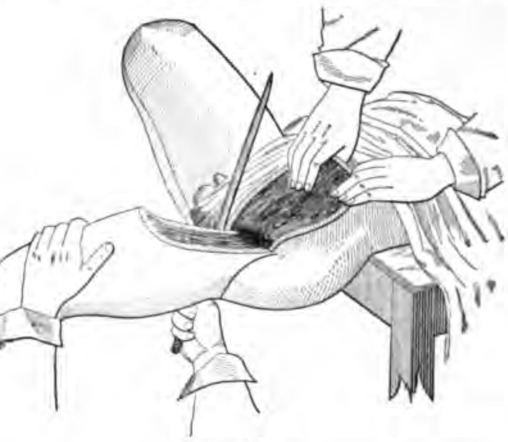

FIG. 194.

the artery and vein a strong ligature.* By displacing the pectineus muscle the obturator artery can be readily found and ligated below the obturator membrane.

The limb being now raised, the surgeon proceeds to cut a semilunar tegumentary flap from the back of the thigh, one inch shorter than the anterior. With an amputating knife the muscles are then severed circularly in front of the joint, "when after liberation of the head of the bone, as in other methods, the operation is completed by dividing through the soft parts posteriorly."

* Volkmann divides the vessels between two ligatures.

in 1888 by Professors Jolly and von Mering for its soporific properties. It is said to occupy a place between chloral and paraldehyde, two parts being equal to one of the former or three of the latter. Its advantage over chloral is, that it has no depressing effect on the heart. Its smaller dose and less disagreeable odor make it preferable to paraldehyde in many cases. It produces a calm, refreshing sleep, which lasts for six or eight hours, from which the patient awakens without any bad symptoms. It is used in insomnia due to nervousness, debility, mental excitement, and delirium tremens, morphiomania, and in fevers. It has not proved of much use when the sleeplessness is due to pain. It does not cause headache, nausea, or deranged digestion. In very large doses it produces a lowered temperature, shallow respiration, feeble pulse, loss of reflexes, and paralysis of extremities. It is given in doses of ♏ xxx.-xlv. Its taste and odor often prove objectionable, and may be disguised by combining with extract of licorice or some aromatic. It may also be used as an enema with mucilage of acacia, in doses of ♏ xl.-xc. *Beaumont Small.*

AMYLOFORM.—A proprietary compound, stated to be a condensation product of formaldehyde and starch. It is a white powder, odorless, non-toxic, and insoluble in all ordinary solvents, and is used as a substitute for iodoform.

Dextroform is a similar compound of formaldehyde and dextrin, and it possesses the advantage of being soluble in water and of setting free its formaldehyde more readily. *W. A. Bastedo.*

AMYLOID.—(From *amylum*, starch, so called from the fact that the amyloid substance gives with iodine and sulphuric acid a reaction similar to that of starch. Also called waxy, lardaceous, or albuminous degeneration. French, *Dégénérescence amyloide;* German, *Amyloidentartung, Wachsentartung, Speckentartung.*)

The term amyloid degeneration is applied to the appearance, in the body, of a clear, colorless, shining, homogeneous, highly refractive, and translucent body, greatly resembling wax, firm in consistency, and possessing but little elasticity. When treated with iodine solution, it takes on a mahogany color, which in marked cases may become bluish or green (see Plate VII.) If the specimen thus treated is further subjected to the action of dilute sulphuric acid, zinc, or calcium chloride, the mahogany color may be intensified, or a play of colors—red, violet, blue, or green—may be produced. This action, however, does not always occur.

Because of this characteristic reaction with iodine, so analogous to that of starch, Virchow was led to believe that the newly discovered substance was devoid of nitrogen and closely allied to cellulose or starch, and for this reason gave it the name amyloid. It was further designated as "animal cellulose." On the other hand, Meckel believed it to be closely related to cholesterin. Several years after, the chemical investigations of Friedrich, Kekulé, Schmidt, Rudeneff, and Kühne proved conclusively that the so-called amyloid was in reality a nitrogenous body of an albuminous nature. According to Tschermak, it is a coagulated, albuminous substance, and is possibly an intermediate product between the proteids on one side and fat and cholesterin on the other.

It bears also a very close chemical relation to the hyaline deposit found in blood-vessels and connective tissue, as is shown by the fact that amyloid organs sometimes contain hyaline masses in no way distinguishable from the neighboring amyloid except by the application of specific staining methods. In some cases the periphery of large masses of amyloid give the reactions for hyalin and not for amyloid. Litten found that pieces of amyloid tissue lost their characteristic reactions and became changed to hyaline when introduced into the abdominal cavity of animals. The strong general resemblances between the two bodies, their similarity of location, and the frequent coincidence of occurrence make it very probable that the two substances are very closely related and that they may change from one to the other.

Amyloid differs from other albuminous bodies in its characteristic staining reactions, in its resistance to the action of pepsin, and in its very slight tendency to putrefaction. When exposed for a long time to the action of the gastric juice it slowly dissolves, so that it is possible that its resistance to pepsin and agents of putrefaction is due to its great density, which hinders the penetration of fluids. It is likewise resistant to acids and alkalies, and is not altered by alcohol and chromic acid. Through the prolonged action of dilute sulphuric acid tyrosin and leucin may be obtained from amyloid, its end products thus harmonizing with its albuminous nature.

But little is known with certainty regarding the causes and nature of amyloid formation. It is one of the most common pathological conditions of the body, and may exist as a local change, or be widely distributed through many organs and tissues. It usually occurs as a slowly progressing disease in association with various cachectic conditions. In these cases of widespread formation it must be the result of some general disturbance of metabolism. The amyloid substance does not exist in the blood as such, but the material from which it is formed is, without doubt, derived from the blood. Though called amyloid degeneration, the process is not to be classed with the true degenerations of cell protoplasm, but is rather to be regarded as a pathological deposit, in the tissues, of a substance derived from the circulation. It has been conclusively shown that the cells of the affected tissue take no active part in the formation of amyloid. The location of the deposit is practically always in the walls of the blood-vessels or in the interstices of the tissues immediately around the vessels, and the organs which show the greatest degree of the change are those abundantly supplied with blood, as the liver, spleen, and kidneys. It is possible that the amyloid substance is the result of the union of some albuminous material derived from the blood with some constituent of the tissues, and that the lowered vitality of the tissues resulting from general or local disturbances of nutrition favors its formation; or, as the result of impaired nutrition, a peculiarly modified albuminous body may be separated from the blood through the activity of the secretory cells of the blood-vessel walls. As the chief seat of the amyloid deposit is always just outside the endothelium of the blood-vessels, it becomes highly probable that it is a *product of endothelial cell activity*, and is deposited in the tissues outside the endothelium in a manner analogous to the deposit of hyalin, lime salts, or silver pigment. This pathological secretion may be the result of general changes in the circulation whereby the secretory function of the cells of the vessels is changed, or the changes may be primary in the cells themselves. The fact that local deposits of amyloid occur without apparent general changes of nutrition favors this view. In the widespread deposit of amyloid in cachectic conditions the pathological condition of the cells may be produced by the altered state of the blood; in the local deposits it may be due to local changes in the vessels, caused by local inflammatory processes.

In the majority of cases the deposit of amyloid appears as a secondary phenomenon in various cachectic states, being most commonly associated with chronic tuberculosis of the lungs and bones, chronic suppurative processes, syphilis, chronic dysentery, and leukæmia. In these diseases the most extensive deposits may be found. It rarely occurs in the cachexia of carcinoma, and usually only when there is ulceration of the growth. It is also found, though less frequently, in association with pseudoleukæmia, chronic arthritis, nephritis, chronic diarrhœa, typhoid fever, prolonged malaria, and after severe forms of rachitis. Occasionally there may occur in children a widespread deposit of amyloid without any discoverable cause.

According to Cohnheim, amyloid deposits may become well developed in from two to three months. Czerny and Krawkow claim to have produced it in animals in

from three to sixty days through the establishment of suppurative processes, caused by injections of turpentine and of staphylococci. Experiments made in Ziegler's laboratory throw doubt upon these investigations. As a rule, the formation of amyloid takes place very slowly. It occurs most frequently between the tenth and thirtieth years, but may be found in new-born infants (congenital syphilis), and also in extreme old age.

Localization.—Amyloid occurs most frequently as a widespread deposit in one or several organs, especially affecting the spleen, liver, kidneys, and lymph glands. Next to these the mucosa of the intestine, the adrenals, and the omentum may show a marked degree of the change. In all of the organs it may occur to such an extent that it affects greatly the gross appearance. It is less frequently found in the intima of the great vessels, mucosa of the respiratory and urinary passages, thyroid, lungs, ovaries, testicles, prostate, bone marrow, salivary glands, and muscle. In these its occurrence is usually so limited that its presence can be made out only by means of the microscope.

The degree of the change varies very much in different cases. The kidneys may show a marked deposit, while the other organs may contain but little amyloid; in other cases the liver or spleen may be the chief seat of the change. The primary seat of the deposit and the order in which the different organs are affected vary with the individual case, and bear no definite relation to the associated pathological condition.

Local deposits of amyloid occur in single lymph glands following inflammatory processes (mesenteric glands after typhoid), in scars, local inflammations, hyperplastic growths, tumors (osteo-fibroma of tongue, chondroma of lung), in the tongue, tonsils, and larynx following syphilitic processes, and in the scars of liver gummata. Klebs obtained the amyloid reactions in a hard chancre. Numerous authors have found amyloid in pathological conditions of the cornea and conjunctiva (trachoma, staphyloma, etc.). It has also been found in old blood clots and thrombi, and frequently in the cartilages of old individuals who have presented none of the pathological conditions with which amyloid is usually associated. These local deposits of amyloid sometimes form tumor-like masses under conditions in which it is impossible to establish any relationship between them and any other pathological process. The corpora amylacea found in the prostate, nervous system, lung, etc., sometimes give a reaction resembling that of amyloid (see *Corpora Amylacea*).

Macroscopical Appearances.—When the deposit of amyloid is at all extensive, it is readily recognizable by the naked eye; but the degree and nature of the deposit and of the associated degenerative conditions vary so much that no general description can be given which will apply to all cases. The organ is usually swollen and plumper than normal, its edges are more rounded and its fissures deepened. Its volume and weight are increased, the latter sometimes four- to fivefold. The consistency is greatly increased; in severe cases the organ may have a wooden hardness. There is also a great loss of elasticity, so that pressure indentations made upon the surface of the organ remain for a long time. The blood-content of the affected organ is usually greatly diminished, so that its color becomes grayish or yellow if much fatty change is present. Very characteristic is the shining, translucent, waxy appearance of the cut surface, resembling that of bacon (lardaceous). The differences in histological structure of the various organs lead to individual appearances when amyloid is present, and these will be described separately.

The iodine test is best applied to fresh tissue. A moderately strong Lugol's solution should be used after washing out the blood, as the color resulting from the combination of the red hæmoglobin and yellowish-brown iodine very closely resembles the mahogany red of the amyloid. The iodine solution is poured over the freshly cut surface, allowed to stand for a minute or so, and then washed off. The amyloid areas are reddish brown, the non-amyloid ones yellow. If dilute sulphuric acid is now applied, the amyloid portion becomes dark green to black, or dark violet, while the unaffected tissue is of a clear gray color. This gross reaction is plainly seen, as a rule, only when the amyloid deposit is marked; but sometimes, as in the intima of the large arteries, it may be brought out very distinctly when no other appearances point to the presence of amyloid (see Plate VII.).

Microscopical Appearances.—Microscopically, amyloid appears as a homogeneous, hyaline substance, of rather high refraction, which is deposited almost exclusively in the walls of the capillaries and smaller arterioles. In its earliest stages it appears as a homogeneous layer outside the endothelium, but in more advanced cases, owing to the atrophy of the intervening tissue, the masses of amyloid increase greatly in size and may finally become confluent, so that the entire tissue, or a large part of it, may be replaced by amyloid. In this way large nodules or tumor-like masses are formed. It must be emphasized, however, that in its earliest stages the first appearance of amyloid is always next to endothelium.

It is never deposited in living cells. The tissue cells proper take no active part in the process, and the changes found in these cells are to be regarded as secondary. The lumen of the affected vessel is soon narrowed by the increasing deposit, and the resulting disturbance of blood supply leads to degenerative changes (atrophy and fatty degeneration) of the cells of the affected region. The deposit of amyloid between and around the cells near the blood-vessels leads to similar changes. The individual vessels are not equally affected throughout, and different vessels of the same organ may show the change in very different degrees.

The microscopical appearance of amyloid in sections stained with hæmatoxylin and eosin is so similar to that of hyalin that a differential diagnosis between the two deposits can be made only by means of some specific staining reaction. Of these the best and most practical is the Van Gieson's method. The sections are overstained in hæmatoxylin and then stained for one-half to one minute in a concentrated water solution of picric acid to which enough of a concentrated water solution of acid fuchsin has been added to give it a distinctly red color. By this method amyloid is stained a pinkish brown or yellow, while hyalin takes a deep red color.

The iodine reaction does not show so well in hardened material, so is best applied to fresh tissue. The specific reactions of amyloid with various aniline dyes are classic in the history of microchemistry, and it is largely to the wonderful amount of interest bestowed upon these that this branch of pathological technique owes a very great part of its development. The aniline stains most commonly used are methyl and gentian violet, methyl green, and iodine green. The amyloid tissue is best hardened in alcohol and cut without embedding. The sections are then stained for five to ten minutes in a two to five per cent. solution of the stain, differentiated with dilute acetic acid, and mounted in glycerin or syrup. With all of these stains amyloid exhibits a metachromatosis. Methyl and gentian violet and iodine green stain the amyloid portion ruby red, while the non-amyloid is stained blue. Methyl green stains the amyloid a sky-blue, the non-amyloid a bright green. None of these reactions is permanent; the sections so treated gradually fade. On the whole, the Van Gieson's method, which can be applied to either paraffin or celloidin sections, is the most convenient and practical stain for the differentiation of amyloid.

Liver.—This organ is very frequently the seat of amyloid deposit. Outside the endothelium of the liver capillaries, between it and the liver cells, there is deposited a layer of amyloid, which, as it increases in thickness, presses upon the liver cells and separates them from their normal relations with the blood, so that they undergo atrophy and degeneration, and finally may entirely disappear. The amyloid masses thus become confluent, the capillary walls are pressed together, and the only cells

left in the area are the endothelial cells, which may persist for a long time. The intermediate zone of the lobule is almost always affected to a greater extent than either the central or the peripheral one. The walls of the larger blood-vessels may also show the deposit. In more advanced cases the entire lobule may be replaced by amyloid. This marked change is usually confined to single scattered lobules, so that these appear to the naked eye as grains of boiled sago (sago liver). More rarely the greater part of the liver may be replaced by confluent masses of amyloid, whereby the organ acquires a wooden hardness and on section resembles the translucent portions of bacon (*Speck-Leber*).

Spleen.—In the spleen the amyloid deposit takes place in the fine reticulum of the pulp beneath the endothelium of the blood spaces. The follicles may alone be affected, appearing enlarged and translucent like boiled sago (sago spleen); or the chief deposit may be throughout the pulp, or may involve both pulp and follicles (*Speck-Milz*, lardaceous spleen). The arterioles of the follicles are often the only portions of the organ which show the deposit, and it is in these that the earliest appearance of amyloid in the body as a rule occurs.

Kidney.—The afferent arterioles of the glomeruli are usually first affected, then the glomerular capillaries and efferent vessels, and finally the smaller vessels throughout the entire organ. The change is never so marked in the medullary pyramids as in the cortex, but it may appear early in the straight vessels of the former. As the disease advances the deposit extends from the intertubular capillaries to the basement membrane of the tubules, which may appear as if surrounded by a hyaline ring. The intima of the larger branches of the renal artery may show small and irregularly scattered deposits. Since the glomeruli are the chief seat of the deposit, they appear on the freshly cut surface of the organ as small, firm, translucent dots usually about the size of pinheads.

Lymph Glands.—Extensive amyloid deposit is not common in the lymph glands, but scattered masses are very frequently found in them; and the walls of their small arterioles usually show a moderate degree of change in all cases in which the liver, spleen, and kidneys are extensively affected. Local inflammatory changes, both of the lymph glands and the tonsils, are very frequently accompanied by the formation of small masses of amyloid in connection with hyaline deposit, and the close relation of these substances is nowhere else so well shown as in these organs. In advanced cases the deposit may extend from the neighborhood of the capillaries into the reticulum, causing atrophy of the lymphadenoid cells.

Muscle, Fat Tissue, etc.—In striated muscle amyloid deposit is rarely found. It has been found in the tongue and in the muscles of the larynx in the shape of nodular masses. The deposit takes place first in the walls of the capillaries of the endomysium, and as it increases in size the sarcolemma comes to be surrounded by a clear, hyaline mass. As the muscle fibre is thus separated from its blood supply it undergoes atrophy and degeneration, finally disappearing so that the deposits of amyloid become confluent into nodular masses. A similar process may take place in heart muscle and in unstriped muscle, but is of rare occurrence. The amyloid deposits in striped muscle occur very frequently in the scars of gummata, but occasionally no evidences of preceding pathological changes can be made out. Adipose tissue is often extensively affected by amyloid disease, the deposit taking place in the walls of the larger blood-vessels and of the intercellular capillaries, so that the fat cells come to be surrounded by a thin hyaline layer.

Mucous Membranes.—The mucous membranes of the respiratory tract are very rarely affected. Scattered deposits may occur in the mucosa of the stomach and intestine, producing more or less extensive thickenings of the mucosa, which show the characteristic homogeneous, glassy appearance of amyloid. Large elevations may undergo ulceration, and at the bottom of the ulcer remains of the amyloid may be preserved. The large intestine is more frequently affected than the small. The deposit is in the walls of the capillaries of the mucosa and submucosa. Only in very rare cases is amyloid found in the mucosa of the genito-urinary tract.

General Nature of Amyloid Disease.—As stated above, the formation of amyloid is almost always secondary to other processes which are ulcerative or inflammatory in character, and of infective nature. While not in itself a true degeneration of cell protoplasm, the process is essentially degenerative in character, in that it leads to marked disturbances of nutrition. The deposit in the walls of the blood-vessels leads to partial or complete obliteration of their lumina, thus producing permanent interference with the circulation. As a result of this disturbance of nutrition, atrophy, fatty degeneration, or necrosis of the tissue cells takes place. The pressure of the amyloid deposits between the cells leads to similar results. Fatty degeneration and infiltration are almost always present to a greater or less degree in amyloid disease, and to a certain extent must be regarded as coincident processes produced, perhaps, by the same general disturbances of metabolism which give rise to amyloid. Severe anæmia is usually associated with the condition, and death takes place as a rule from a gradually increasing marasmus.

Symptoms.—The marked alterations in the structure of the affected organs and tissues lead to functional disturbances, which, however, may be very slight when compared to the extent of the deposit. The general clinical picture of the condition will vary, of course, with the organ affected and with the extent of the disease, so that a comprehensive description is not possible. Moreover, from the nature of the case, it is manifestly difficult or impossible to separate the symptoms of amyloid deposit from those of the disease leading to or associated with it. The nature of the primary process will modify very much the clinical appearances dependent upon the amyloid change. Frequently the beginning of the condition is shown by a rapid increase in the marasmus already existing, and by the enlargement of liver and spleen. These phenomena are always more marked in syphilis and in chronic ulcerative processes than in pulmonary tuberculosis. In such conditions as chronic varicose ulcers of several years' standing a rapid increase of the cachexia is usually pathognomonic of amyloid disease.

Associated with enlargement of the liver certain disturbances of digestion go hand-in-hand: absence of bile pigment in the fæces, fecal decomposition, meteorism, etc. Icterus is rarely present, and ascites only as associated with a general hydræmic or cachectic anæmia. Marked amyloid deposit in the kidneys is not always shown by disturbances of its function. The urine may show no changes; but as a rule albumin is present, the amount is increased, and the sediment contains hyaline casts, though usually not in great numbers. The latter never give the amyloid reaction, in spite of the repeated statements that they do. As amyloid deposit in the kidneys is, in the majority of cases, associated with chronic inflammatory changes, the character of the urine may vary greatly. Marked amyloid disease of the intestine is usually accompanied by foul diarrhœa.

Diagnosis.—The nature of the primary affection must first be considered. If in patients affected with any one of the chronic diseases known to be associated with amyloid (chronic tuberculosis, syphilis, chronic suppurative processes), painless swellings of the liver and spleen arise, in association with albuminuria and extreme paleness of the skin and mucous membranes, the diagnosis of amyloid is made very probable.

Duration.—The earliest stages of amyloid change cannot be ascertained clinically. It is probable that in many cases the process develops through several or even many years with alternate periods of improvement and exacerbation. It may, however, develop within shorter periods, as in a case observed by Cohnheim, in which suppuration of bone after a fracture led to well-developed amyloid disease within a few months. The duration of well-marked cases depends upon the organ chiefly af-

FIG. 1.

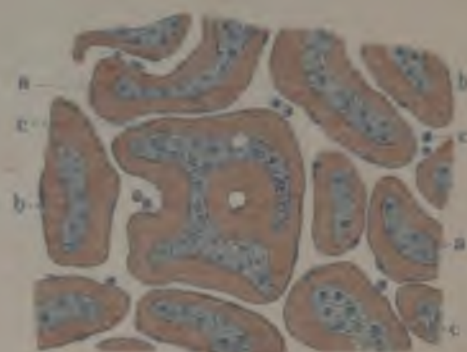

FIG. 3.

FIG. 2.

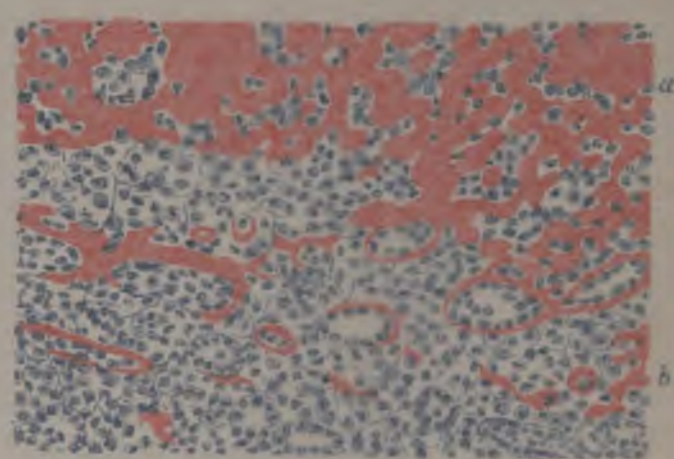

FIG. 4.

AMYLOID DEGENERATION IN DIFFERENT ORGANS

FIG. 1.—Section of an Amyloid Liver, Showing the Effects of Staining it with a Solution of Iodine. a, Normal liver tissue; b, tissue that has undergone amyloid degeneration; c, Glisson's capsule. Magnified [illegible] diameters. (Ziegler.)

FIG. 2.—Amyloid Kidney, stained with Aniline Violet. The amyloid is stained red. The change is most marked in the capillaries of the glomeruli and in the small arteries, and is seen also as a [illegible] line surrounding the [illegible] of the tubules. Magnified [illegible] diameters. [illegible]

FIG. 3.—Section of an Amyloid Liver After being Treated with Methyl Violet and Acetic acid. a, Elongated masses of liver cells; b, amyloid substance; c, [illegible] of the capillaries; d, colorless blood corpuscles. Magnified 150 diameters. (Ziegler.)

FIG. 4.—Amyloid Degeneration of the Follicles and Pulp of the Spleen. ([illegible] violet; hydrochloric acid.) a, Follicular tissue in a [illegible] stage of amyloid degeneration; b, pulp tissue in which the degeneration has begun. Magnified 300 diameters. (Ziegler.)

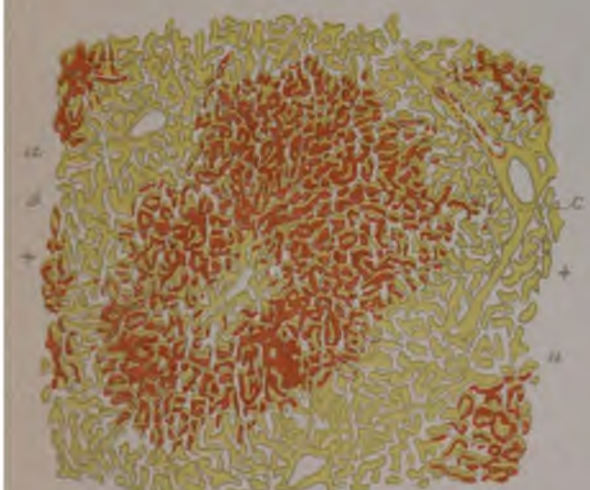

FIG. 1.

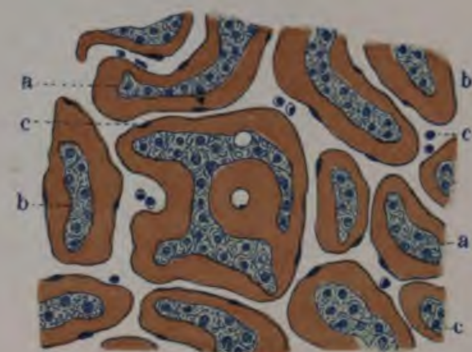

FIG. 3.

FIG. 2.

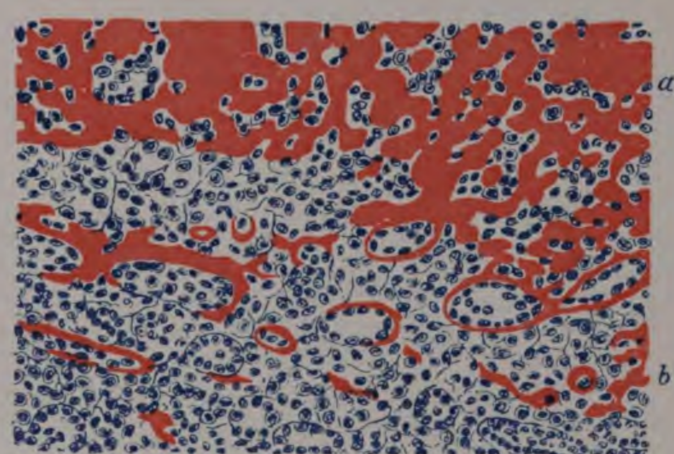

FIG. 4.

AMYLOID DEGENERATION IN DIFFERENT ORGANS

FIG. 1. Section of an Amyloid Liver, Showing the Effects of Staining with a Solution of Iodine. *a*, Normal liver tissue; *b*, tissue that has undergone amyloid degeneration; *c*, Glisson's capsule magnified 5 diameters. (Ziegler.)

FIG. 2.—Amyloid Kidney, Stained with Aniline Violet. The amyloid is stained red. The deposit is most marked in the capillaries of the glomeruli and in the small arteries, and is seen also as a fine hyaline ring surrounding the membrana propria of the tubules. Magnified 400 diameters. (Ribbert.)

FIG. 3.—Section of an Amyloid Liver After being Treated with Methyl Violet and Acetic Acid. *a*, Elongated masses of liver cells; *b*, amyloid substance; *c*, endothelium of the capillaries; *e*, colorless blood corpuscles. Magnified 150 diameters. (Ziegler.)

FIG. 4.—Amyloid Degeneration of the Follicles and Pulp of the Spleen. (Alcohol; methyl violet; hydrochloric acid.) *a*, Follicular tissue in a marked state of amyloid degeneration; *b*, pulp tissue in which the degeneration has begun. Magnified 300 diameters. (Ziegler.)

fected. Extensive changes in the kidney are much more serious than those of the liver or spleen, as they lead to death within a few weeks or months.

PROGNOSIS.—This is in general unfavorable. It is probable that amyloid, when once formed, is not removed from the site of deposit. In all cases in which the condition is so marked that the diagnosis is certain, death usually occurs within short periods. Temporary improvement may take place; and in some cases, especially after operation for chronic purulent conditions of bone, the disease apparently comes to a standstill, marked general improvement takes place, the liver swelling decreases, and the albuminuria disappears. It is, of course, impossible to say to what extent these symptoms were due to the amyloid disease. A similar improvement has been noticed as the result of a prolonged inunction cure in a case of amyloid associated with syphilis. Corneal tumors may slowly disappear under the influence of local irritation and inflammation.

TREATMENT.—For the well-established condition it is hardly probable that treatment will avail, though iodine, ammonium chloride, potassium iodide, dilute nitric acid, etc., have been recommended. The improvement of the local or general primary condition is, of course, the most important therapeutic line to be followed; and in connection with this the general improvement of nutrition. Of far greater importance are prophylactic measures, even to the extent of such radical procedures as amputation in cases of chronic varicose ulcerations, chronic suppuration of bones, etc., in which persistent operative and therapeutic measures have been without result. *Aldred Scott Warthin.*

ANABOLISM. See *Metabolism.*

ANACARDIACEÆ, or TEREBINTHINACEÆ.—(The Cashew family.) A remarkable and important family of some fifty-nine genera, chiefly tropical or subtropical, exceedingly varied in the nature of its products. The mango, the cashew, and the spondias or hog-plum, are important fruits; those of Pistacia furnish a well-known flavoring agent, while its bark yields the commercial resin mastic; the milk juice of several Japanese species of Rhus furnishes Japanese lacquer, and the leaves and fruits of other species of this genus yield tanning agents. The oil which abounds in several species of Rhus (more properly called *Toxicodendron*), and in some other genera, acts as a powerful cutaneous poison. (See *Poisonous Plants.*) *H. H. Rusby.*

ANÆMIA, PERNICIOUS.—(Synonyms: *Progressive perniziöse Anämie*, Biermer; *Idiopathic anæmia*, Addison; *Essentielle Anämie*, Lebert; *Essentielle maligne* or *Essentielle febrile Anämie*, Immermann; *Perniziöse Anämie*, Quincke; *Anémie progressive*, Lepine.)

DEFINITION.—Pernicious anæmia is a grave form of anæmia which is characterized by a reduction in the total amount of the blood and by a change in its physical, anatomical, and chemical characters. The blood is thin and pale and not coagulable. The red corpuscles are lessened in number and changed in size and shape. It is a peculiar circumstance that the adipose tissue is generally maintained, while at the same time secondary fatty degeneration of the heart is almost always found to be present. The disease is distinguished, clinically, by the symptoms of grave anæmia, often by an irregular fever, retinal hemorrhages, and hemorrhages underneath the skin and from mucous membranes. Its course is usually progressive, its termination fatal, its duration from seven weeks to from two to three years. Complications are rare; death is due to exhaustion, to syncope, to œdema of the lungs, or to cerebral complications.

This symptom complex may be dependent on some evident anatomical change or it may have no demonstrable organic basis. Thus we distinguish secondary or symptomatic progressive pernicious anæmia and a primary, essential, or cryptogenic form. Some authors limit the term pernicious anæmia to the latter group, but it seems better, in view of the identity of the two conditions anatomically and clinically, to apply the term to that peculiar form of anæmia which possesses the characteristics enumerated above, whatever its cause may be. In the secondary form of pernicious anæmia the symptoms of the blood changes dominate the clinical picture so that the symptoms referable to the causal lesion are comparatively insignificant, and the anæmia becomes practically a disease *per se*. This characteristic marks the distinction between pernicious anæmia and simple chronic anæmia in which the symptoms of the primary disease hold the first place, although the anæmia may be severe.

HISTORY PREVIOUS TO 1872.—The publication by Biermer, in 1872, of a series of cases of this disease, and his assertion that he was the first to recognize it, aroused the latent energies of the English, so that since then they have justly and successfully shown that to one of their countrymen is due the credit of having identified it long before that time. Addison certainly had observed and taught the clinical course of the disease, and had made inquiries into its pathology. He clearly established that what he called idiopathic anæmia was an independent affection, and so impressed it upon his colaborers and students that ever since then it "has not been lost sight of at Guy's." The wards of that hospital have furnished most of the cases for English memoirs, and its reports contain many observations and discussions on this disease. Prior to Addison, Coombe, Marshall Hall, and Barclay reported isolated cases of fatal anæmia. Since then, and before Biermer's publication, Wilks, Bristowe, Leared, and Habershon made contributions to our knowledge of the disease. The labors of Taylor, of Pye-Smith, of Mackenzie, and of others have clearly proven the fact of English priority. Professor Eichhorst, in his elaborate monograph, admits these claims, while Pepper, in the United States, was one of the earliest to point out the credit due Addison. In the mean time, the French, through Lepine, presented their claims of priority in the early recognition of the disease. Lepine justly admits the valuable work of Addison and his followers, but says that Andral was the earliest observer, and that Piorry, Cazenave, and Perroud had recognized the affection, the latter detailing four cases, with autopsies. A dissenting voice arose among the Germans. Lebert claimed that he had, in separate papers, described this disease, but the evidence from them shows that he had confused chlorosis with pernicious anæmia. Lately, it has been found that American physicians can enter claims of priority for one of their countrymen. Channing described cases of fatal anæmia in connection with, and independent of pregnancy as early as 1832. Not only was he himself perfectly familiar with it, but so also were many of his associates.

HISTORY SINCE 1872.—The time of the publication of Biermer's essay on "Progressive Pernicious Anæmia" makes an epoch in the history of this strange disease. He not only embodied in his essay as faithful a portrayal of the disease, as Addison and others had done, but he added to it more accurate accounts of the blood changes and the occurrence of retinal hemorrhages. Moreover, he so impressed the medical world with the important results of his observations that since then the knowledge of the disease, instead of being confined mostly to England, has become universal, and multitudes of observations have been in a short time added to the previous comparatively scanty data. In 1874 Immermann, in 1875 Zenker, and in 1876 Quincke, made valuable contributions to the study of the disease, while in 1877 important and elaborate monographs, by Müller and Eichhorst respectively, appeared. Since then German literature has been rich in observations of isolated cases. Among Englishmen, Pye-Smith, in 1875, published two cases in the *Deutsches Archiv*, and since then, among others of his countrymen, Bramwell, Mackenzie, Finney, Coupland, and William Hunter have written interesting and important articles. In America, Pepper, Howard,

Osler, Stengel, Thayer, Cabot, and others have made valuable observations. From a study of its history we find that a true conception of pernicious anæmia has been arrived at only through the combined labors of many observers. Thus Addison clearly defined the limitations of the primary type of the disease; Wilks first observed some of the blood changes; Biermer described the retinal hemorrhage. Then Immermann showed the relations and importance of the febrile process; Quincke contributed to the microscopical appearances of the blood, and showed its extreme deficiency in hæmoglobin, and the occurrence of siderosis. About the same time Eichhorst published the blood changes which he considered pathognomonic, and Pepper first demonstrated the possible relationship of this disease to an affection of the bone marrow. His work was corroborated by Scheby-Buch, Cohnheim, and Osler. The latter author has also made valuable investigations on the appearances of the blood. Professor Howard was the first to consider the relations of this form of anæmia to other forms, and to show that any form of anæmia may become pernicious. Granting the credit due these eminent observers for the work they have done, it is not detracting from it to say that about the year 1830 a coterie of physicians in and about Boston were well aware of the occurrence of fatal anæmia without assignable cause, and that they had discussed its nature and clinical course in their societies, and had published their observations to the world.

Etiology.—This is obscure. It is extremely difficult to reckon the influence of the age, the sex, the habits, and the condition of life as predisposing factors; and at the same time our want of knowledge of the pathology of the disease makes it as difficult to determine the exciting cause. In fact, all that can be said is that under certain circumstances and influences the disease develops more frequently than under others, without our being able to give a reason. According to some (Coupland, Eichhorst) it is divided about equally between the sexes. Bristowe says it is more frequent in the males. Müller, Immermann, and Biermer give predominance to the female sex. It is found to occur as early as at the age of five, or as late as at sixty-eight.

The following table, taken from Pye-Smith's very able article, shows well the relations of age and sex, according to various authors. "Many of the cases are common to all four lists."

	H. Müller.		Coupland.		Eichhorst.		Pye-Smith.
	Male.	Female.	Male.	Female.	Idiop.	Second.	
Under 15....	0	0	1	0	0	1	6
15 to 20.....	2	4	2	4	2	1	4
21 to 30.....	2	9	8	18	4	17	29
31 to 40.....	1	19	9	16	8	22	26
41 to 50.....	2	2	19	9	4	16	21
51 to 60.....	2	1	14	7	4	9	13
61 to 70.....	..	..	3	1	1	1	4

It is thus seen that early adult life is the period of greatest liability. The position in life and the occupation seem to have some predisposing influence. In Germany the poorer classes, half-starved ordinary laborers, are more frequently attacked. There are notable exceptions to this in England and in this country. Cases have been reported of the wealthy and the well nourished being affected. Intemperate habits are frequently recorded in the reports. The residents of the country are as often affected as those living in the city, if not oftener. The occurrence of the disease with unusual frequency in parts of Switzerland led Immermann to suggest an endemic influence. Though the disease is not so frequent in other countries, it is sufficiently so to disprove such statements.

Aside from these factors, that probably act merely as predisposing causes, there are a number of conditions that have been shown to stand in the closest causal relationship to the anæmia; chronic suppuration, venereal excess, and diarrhœa appear to be the exciting causes in certain cases. Repeated bleedings, such as occur in hemorrhoids, may lead to this condition. Atrophy and sclerosis of the mucous membrane of the stomach and intestines seem often to be a cause. Infections, particularly syphilis and typhoid fever, are held to account for some cases. Biermer in his earliest communication recognized the causal relation of pregnancy and parturition to the disease. Two intestinal parasites, the Ankylostomum duodenale and the Bothriocephalus latus, cause a form of pernicious anæmia, probably by the elaboration of a poison. Many observers have insisted upon the occurrence of shock, grief, or anxiety as exciting causes. This is notably the opinion of Lepine, Wilks, and Coupland. Curtin, not knowing of the views of these men, long ago formulated such an idea, and has recorded cases which appear to have arisen from such cause.

Morbid Anatomy.—The appearance of the body after death is characteristic. The entire surface indicates an absence of blood—extreme pallor of the face, the extremities, the trunk, and the external mucous membranes, so that, if not for the dirty-yellow or straw-colored appearance of the face and hands, a sudden profuse hemorrhage might be considered the cause of death. On the extremities, the back of the hands, and the dorsum of the feet, the ankles and wrists, minute extravasations of blood are often seen. They vary from the size of a pin's head to that of a split pea, and are purple or yellow red in color. Œdema of the feet and ankles, of the hands and of the face is sometimes seen. The œdema may be limited to the eyelids or may be general. It may vary from this slight amount to a universal anasarca. Wasting of the body is often not marked; in fact, this absence of emaciation was thought in the early history of the disease to be the rule, but a few well-authenticated cases are recorded in which it was present. The presence of fat—for it is the adipose and not so much the muscular tissue that remains—is more noticeable in the abdominal walls than in any other region of the body. It is said that rigor mortis does not develop early after death.

On section, the most striking feature is the bloodlessness of all the tissues. A large proportion of cases exhibit the presence of subcutaneous œdema in the parts indicated above, while œdema of the lungs and meninges is common. Passive effusions into the serous cavities occur less frequently; they are generally small in amount, and hence are not appreciated during life. Considerable ascites, hydrothorax of one side, and hydropericardium are changes which have been seen only rarely. The exuded serum is of a deeper yellow color than usual. The preservation of adipose tissue is remarkable, not only in amount, but also in appearance. The subcutaneous and subserous accumulations remain, and the appendices epiploicæ are well preserved. The color of the fat is bright, or sulphur yellow, this being due probably as Lepine suggests, to ferrous sulphide. The muscles are generally firm and red, though the bulk is reduced. Fatty degeneration of the diaphragm and of the abdominal muscles has been observed.

In addition to the absence of emaciation and the extreme bloodlessness of the body, one of the characteristics of pernicious anæmia is the occurrence of small hemorrhages. These are seen in the skin as minute extravasations; they are found underneath the serous membranes—the pericardium, the peritoneum, and rarely the pleura—as minute points and specks; under the endothelium of the blood-vessels they have also been seen. They frequently occur in the brain substance as capillary hemorrhages. Similar hemorrhages are found in the mucous membrane of the œsophagus, the stomach, and the intestines, in the lungs and upper air passages, and in the bladder. The most frequent seat of these extravasations, however, is the retina. These hemorrhages are due to rupture of capillaries on account of the diseased state of their walls, or to diapedesis.

The last general change that is often seen on section of the body is the occurrence of a dark-gray staining of the organs. This has been proven to be due to an excess

of iron in the tissues. Rosenstein found 0.5187 per cent. of iron in the liver, 0.2275 per cent. in the spleen, 0.0422 per cent. in the kidneys. Quincke found 0.6 per cent. metallic iron in the liver and 0.32 per cent. in the kidneys in one case. In another case the liver contained 2.1 per cent. The iron was seen in the liver cells as small granules. Iron has also been found in the tissue of the lungs and of the pancreas, and in the peritoneum. Purser found the dried kidneys to yield 0.0352 per cent of iron. This increase of iron goes hand-in-hand with diminution of hæmoglobin. Oidtman (quoted by Rosenstein) found, on analysis, the healthy liver to contain 0.08 per cent. and the spleen 0.15 per cent. of iron.

The blood, extremely small in amount, is collected in the heart and larger venous trunks. Attempts have been made to estimate the total quantity of blood, but the results are naturally uncertain. Quincke, in two cases, computed the blood to be 5 per cent. and 4.34 per cent. of the body weight (8 per cent. is considered normal). The small amount of blood in the body can be appreciated during life by attempts to secure some for examination. A deep thrust of a needle in an artificially congested finger, or even an incision, is required to obtain a few drops. It is thin and watery, stains the hands as does nitric acid, or looks like muscle washings or weak coffee. Coagula are rarely found in the cavities of the heart and the vessels. If present, they are soft, friable, and pale or light brown. The blood removed from the body to a test tube, on standing, remains uncoagulated for a long time, although a deposit of the corpuscular elements takes place. The specific gravity of the blood has been found to be as low as 1.025 (Stengle).

On microscopical examinations, the red blood corpuscles are found to be decidedly fewer in number than normal, and they are changed in color, in size, and in shape. Few, if any, changes take place in the white corpuscles. Frequently, however, their number is diminished. A leucocytosis in which the lymphocytes are in excess (sixty per cent.) occurs not infrequently toward the end of the disease. A polymorphonuclear leucocytosis indicates a complication, such as pneumonia or suppuration. Litten recorded a case of pernicious anæmia which passed into leukæmia, and Stengel has observed typical myelocytes in the disease.

The diminution in number of the red corpuscles sometimes goes on to an extreme degree. Quincke records a case in which the number fell to 143,000 per cubic millimetre. Cases are said to have recovered when the red cells were reduced to 360,000 (Worm. Müller); in fact, recovery occurred in the case of Quincke, just mentioned. The smallest number the writer has seen in any case which subsequently recovered was 570,000. The amount of reduction in fatal cases varies from 400,000 to 1,000,000 corpuscles per cubic millimetre. The reduction very often takes place with great rapidity. Thus, in one of Lépine's cases, in ten days the number fell to 378,750. The increase in number is not so rapid when improvement takes place. In the case of Quincke, mentioned above, the cells increased in ten weeks from 143,000 to 1,234,000 per cubic millimetre. In one of the writer's cases the number rose from 570,000 to 1,600,000 in about nine months; a gradual recovery followed.

The red cells vary greatly in size. They are spoken of as microcytes, normocytes, and megalocytes, according to their size. The megalocytes occur in large numbers and may constitute one-eighth of all the erythrocytes. They vary in size from 9 to 14 μ in diameter and have been observed as large as 18 μ in diameter. They do not show the normal biconcave form, but appear globular. Small cells, called microcytes, occur frequently but less constantly. They vary in size from that of a blood plaque up to a normocyte. The normal-sized cells, as well as the larger and smaller ones, frequently show bizarre shapes—oval, bowl-shaped, tailed or pear-shaped, and other forms. Quincke has called them poikilocytes. They occasionally show amœboid movements.

Nucleated corpuscles identical with those occurring in embryonal life occur quite constantly, though seldom in large numbers. They vary in size as do the non-nucleated cells and are correspondingly named microblasts, normoblasts, and megaloblasts. They occasionally show karyokinetic figures. During the course of the disease there are occasional periods, called blood crises, when the number of nucleated cells is greatly increased, and after such a period there is an increase in the number of normal erythrocytes.

The amount of hæmoglobin in the blood is greatly reduced. It is not, however, reduced in the same proportion as are the red blood cells. The amount of hæmoglobin in each corpuscle is increased. The relatively high percentage of hæmoglobin is due chiefly to the large average size of the red blood cells. Eichhorst states that he has observed cases in which the hæmoglobin value of the corpuscles was not above normal. Ehrlich has observed certain erythrocytes whose protoplasm fixes both the acid and the basic stain; these he calls polychromatophile cells. He has called attention to other cells that show fine pigment granules scattered through the protoplasm,—"dotted cells." Both are supposed to be indications of degeneration, though the appearances may signify simply an embryonal condition.

Chemical analyses of the blood have yielded no results that throw any light on the nature of the disease, nor have they detected any changes that would aid in diagnosis. The alkalinity is lessened, the total solids and the albumin are diminished. Probably the loss of albumin from the red cells is greater than from the plasma. Marshall found in one case the total quantity of iron to be one-third the normal.

CYTOGENIC ORGANS.—The spleen is recorded as variable in size—from shrivelled up or very small, through all gradations to enlarged, weighing in one instance 453.5 gm. It generally is more charged with blood than is any other organ. It is not pulpy, but soft and congested, and on microscopical examination there is found an absence of pathological change, save an excess of fibrous tissue in a few cases. Granules of ferruginous pigment have been met with. The lymphatic glands are usually normal. In a few instances the lymphatic glands of the mesentery have been recorded as enlarged, this change being due, as Pye-Smith suggests, to a previous diarrhœa. In one case the lumbar lymphatic glands were enlarged. The marrow of the long bones in a considerable number of cases shows very interesting changes. The appearances described by many observers correspond in the main. The marrow is red or violet colored, and is soft or pultaceous. Its fatty appearance has disappeared, and under the microscope the fat is seen to be replaced by colored corpuscles, non-nucleated, varying in size and in the amount of hæmoglobin which they contain; by nucleated red corpuscles of various size and considerable number; and by cells containing red blood corpuscles. In addition to this, the myeloplaxes, which belong normally in this region, are generally found, though Purser noted their absence. These changes are best studied in the marrow of the shafts of the long bones.

CIRCULATORY APPARATUS.—More marked pathological changes take place in this apparatus than in any other. The heart is normal in size or dilated; the muscular tissue is soft, flabby, pale in color; often the cavities are empty, or they contain soft brown or fawn-colored clots. To the naked eye the appearances of fatty degeneration are most striking. There are some cases in which this change has not been seen; when present, it is most marked on the musculi papillares and columnæ carneæ, and appears as yellow dots, "zigzag striations," or "tabby mottling." The subpericardial fat generally is abundant (Eichhorst). The ventricles are more degenerated than the auricles, it is said, although the writer has observed in two cases an extreme degree of wasting of muscular fibre in the auricles. So marked was it that they transmitted light, the fasciculi of the muscle could be separated, and the endo- and pericardium seemed to make up the auricular wall. The left heart is more markedly degenerated than the right. In one case of the writer's the converse was true. Wilks first de-

scribed the occurrence of fatty heart. Microscopical examination reveals the destruction of muscle striæ and their replacement by fat. The pericardial sac very often contains an excess of serum, rarely any blood. Ecchymoses, however, are quite common underneath this membrane as well as under the endocardium. The valves are normal, or superficial specks of atheroma may be seen on them. Similar changes are found in the intima of the aorta to a slight degree. The capillaries have been studied carefully, and Eichhorst says minute aneurisms may be seen; Mantz describes minute varicose dilatations in the retina, Charcot in the brain. Nykamp opposes these views, and attributes the hemorrhages to diapedesis. Rupture of the capillaries has been observed. Osler saw the small vessels and capillaries of the mesenteric glands studded with fat grains. The arrested development of the heart and aorta and the anomalous distribution of the blood-vessels, said by Virchow to be present in chlorosis, were seen in one of Müller's cases. The aorta at its origin was 1 cm. in diameter, and, in one of the writer's cases, admitted the little finger at the seat of origin of the cœliac axis. The heart, however, was not small.

Respiratory Organs.—Secondarily to the failure of the heart an œdema or hypostasis of the lungs often occurs, and this is in a large number of cases the only morbid condition of these organs. Generally the lungs are extremely anæmic. Sometimes the remains of an old phthisis or an emphysema are seen; very rarely are the lungs the seat of a croupous pneumonia. Hemorrhages underneath the bronchial mucous membrane are found; sometimes there is a bronchitis; pallor of the membrane is noticeable. The pleura is healthy, or the seat of subserous ecchymoses; one cavity may contain serum in a large amount mingled sometimes with threads of fibrin, or both cavities may contain small amounts of serum. The effusion is sometimes sanguinolent.

Organs of Digestion.—The mucous membrane of the gastro-intestinal tract is pale, often also œdematous. Very frequently, however, submucous hemorrhages and hemorrhagic erosions are seen. They have been noted in the mouth, œsophagus, stomach, intestines, and biliary passages. In the stomach, Fenwick, Pontick, and Habershon have found a fatty degeneration of the tubular glands. An inflammation of the gastric mucous membrane has also been recorded. Hyperplasia of the connective tissue of the gastric mucosa, with atrophy of the tubules, is frequently met with. The presence of intestinal catarrh, of chronic follicular enteritis, and of enlargement of the follicles and agminated glands, has been recorded. Dysenteric inflammation of the intestines was observed by Quincke in one case, in the late stages of the disease.

The changes in the mesenteric glands have been previously recorded, as have also to a certain extent those in the liver. That organ is very often anæmic and generally fatty. This fatty degeneration of the liver was specially described early in the history of the disease by Wilks. Perroud thought the hepatic change was primary, the blood change secondary; the fatty degeneration interfering with the formation of blood. The degeneration is seen in the liver cells, large fat drops rendering the nuclei difficult of detection. Deposits of iron pigment have been described by Eichhorst and Quincke in the hepatic cells, the blood-vessels, and the interstitial tissue, in which parts they cause the iron-gray staining referred to previously. Minute extravasations of blood have been seen. Rarely the liver is congested. The size of the organ varies; while it is generally normal, it has been recorded as lessened and also as increased. The surface of the liver is usually smooth and normal; a perihepatitis has been recorded by Müller.

The liver tissue is smooth and compact on section, and the acini are well defined; a nutmeg appearance has been noted in a few instances. The biliary passages are normal or thin, and the mucous membrane is extremely pale. Suppuration of the gall bladder was present in one of Pepper's cases. The gall bladder is generally full of bile.

On microchemical examination, in addition to the presence of iron, Lebert found leucin and tyrosin in abundance in the liver as well as in the pancreas, lungs, kidneys, and spleen.

The pancreas is usually normal. It is sometimes enlarged, and Eichhorst and Quincke found extravasated blood in the interacinous tissue. Huguenin observed fatty degeneration of the glandular epithelium. Iron pigment has been found in the cells in some cases.

Renal and Genital Organs.—Ecchymoses have been observed under the capsule of the kidney, which is readily removed in most cases. The organs are pale and firm on section; often the appearance of fatty change is seen. Microscopical examination reveals the presence of fatty change in the epithelium of the tubules, and in some cases an infiltration with iron pigment is noticeable. The remaining portions of the urinary apparatus are normal, save the occasional presence of submucous hemorrhage.

The suprarenal capsules are normal. Broadbent recorded the occurrence of atrophy of the organ. The microscopical examination of these capsules in the writer's case revealed slight increase of the interstitial tissue, with infiltration of lymphoid elements. The vessels were engorged with blood and small capillary hemorrhages were seen. Pigmentation and slight fatty infiltration of the cells in the capsule were seen, but probably this was not greater than is normal. Granular masses, not unlike colonies of bacteria, were observed.

No changes are found in the sexual organs. Müller noted subinvolution of the uterus in a case of fatal anæmia following pregnancy.

Nervous System.—The brain and spinal cord may be anæmic, and the seat of minute ecchymoses or even (within the brain) of large hemorrhages. The cerebral ventricles sometimes contain an excess of serum or blood. The hemorrhages are chiefly found in the region of the corona radiata or on the surface of the cerebrum. The pia mater or the inner surface of the dura is often the seat of ecchymoses. Eichhorst and Müller observed hemorrhagic pachymeningitis. These authors also have found œdema of the membranes. Microscopically, Eichhorst found no change, save increased pigmentation of the ganglion cells. Schumann ("Diss. Inaug.," Freiburg, 1875) found increase of the nuclei of the cerebral neuroglia. The changes in the vessels have been mentioned. Lichtheim in 1887 first observed scleroses in the spinal cord. Numerous observations since then have confirmed his reports. The posterior columns are chiefly affected, together with less constant changes in the lateral tracts. The irregular distribution of the sclerosis indicates that it is not a systemic degeneration, but is due to the action of a toxic substance.

Since the earliest observations of pernicious anæmia, the appearances of the sympathetic system have been studied. Quickett found, in Addison's case, that the semilunar ganglia had undergone fatty degeneration. Brigidi found (*Lo Sperimentali*, May, 1878; *London Medical Record*, vi., 430) proliferation of the nuclei, increase of interstitial tissue, and granular pigmentation of the ganglion corpuscles of the solar plexus. Wilks and Pye-Smith found no changes in the semilunar ganglia and surrounding plexuses. The writer found pigmentation of the nerve cells and along the nerve fibres, with a slightly granular appearance of the cells. Macroscopically, the ganglia and nerve filaments were unusually prominent. Sasaki (Virchow's *Archiv*, vol. xcvi., 1884) found in a case of pernicious anæmia, of the gastro-intestinal form, sclerosis of the ganglion cells, destruction of some of them, and homogeneous hyaline bodies in Auerbach's and Meissner's plexuses.

Organs of Special Sense.—*The Eye.*—The occurrence of retinal hemorrhages during life has suggested the necessity of making an examination of the fundus of the eye after death. The changes found are not different from those observed in other diseases, as at times in

Late in the disease œdema of the lungs or even hypostatic congestion is liable to occur.

Genito-urinary Symptoms.—These are few; it may be said, in fact, that no complaints are made by the patient of renal symptoms. There are no lumbar pains, and there is no painful or increased frequency of micturition. The urine is clear or dark in color, acid in reaction, varies in specific gravity from 1.010 to 1.020, being usually below 1.015, and is normal in amount. The amount depends on the occurrence of vomiting or diarrhœa, being lessened when these conditions are present. Although the daily amount is about the normal average, cases have been reported in which the amount was increased from 2,000 to 3,500 c.c. daily (Immermann); in some instances the amount was reduced to 800 c.c. (Müller). The excretion of urea is variable and not characteristic, while that of uric acid is increased.

Apart from the changes mentioned in the normal constituents of the urine, few if any pathological products are found. In the later stages of the disease albumin is sometimes observed. It is present in small amount, and its occurrence corresponds with that of some general depression or temporary cardiac embarrassment. Quincke observed a large amount of albumin, in one instance, as did also Müller. The kidneys were highly fatty in the latter observer's case. With the albuminuria that precedes death, there are found hyaline casts (Müller, *op. cit.*, obs. xlviii., p. 239).

Sugar does not occur in the urine of patients with pernicious anæmia. Müller found leucin and tyrosin. Indican is increased in quantity, a fact that favors the theory of the toxic origin of the disease. Blood has been observed at times in the urine; it comes from hemorrhages into the pelvis of the kidney or from the walls of the bladder. Reynolds, in a careful analysis of the urine of one of Dr. Finney's patients, found an increase in the percentage of iron, both when the patient was taking the drug and when it had been discontinued for some time. In the first instance he found 0.7845 grain of iron, and in the second 0.308 grain in 72 ounces of urine. Hunter found in one case 32.5 mgm. of iron in the day's urine (3 to 5 mgm. normal). He has also found quite constantly pathological urobilin.

The genital organs in the male or female are not especially influenced in the course of the disease. In the female the menstruation may be more profuse than normal or it may recur too frequently, and even menorrhagia may develop. The pregnant female will abort, or premature labor will take place.

Nervous System and Special Senses.—Headache and giddiness, with subjective noises in the head and ears and subjective flashes of light, develop in proportion as the anæmia grows profound. There are but few cases in which these symptoms are absent. They are due to the hydræmic condition of the blood. As the disease progresses loss of memory is seen; an apathy and sluggishness of action of the cerebral faculties is quite remarkable, and low wandering delirium gradually advancing to stupor and coma often mark the close of the disease. Rarely convulsions occur, while in some instances paralyses, chiefly limited to monoplegias, have taken place some time before death. These cerebral symptoms are due to hemorrhages within the brain substance and in the membranes, and to œdema of the brain. Symptoms of involvement of the spinal cord occur. They usually conform more or less closely to the symptom complex of tabes dorsalis, or occasionally to that of combined posterior and lateral sclerosis.

One of the symptoms on which Biermer had laid much stress was the ophthalmoscopic appearance of the fundus of the eye. By him, and for a time by others, actual hemorrhages were thought to be constant attendants of this disease. It has been shown, however, that they are present in other cachexiæ and may be absent in this. In two of the writer's cases they were present, but in a third they were absent. Their presence does not imply a fatal termination, nor their absence a favorable one (Coupland). In some instances they were so large as to impair vision and even to cause blindness; generally they are small. They are many in number generally, and are situated around the optic nerve entrance, or they follow the course of the blood-vessels in the nerve-fibre layer. They are most frequently in the lower and outer quadrants. They are seen as black, reddish- or yellow-brown spots, round or oval, sometimes linear-striated or "flame-shaped." The retina is very often clouded or hazy, the vessels are pale, the arteries reduced in size, and the veins enlarged. In some instances an œdema of the disc or a neuro-retinitis has been observed, and Mackenzie noted white patches and yellow spots in the effused blood, due to "leucocytic infiltration, and to degeneration in the disturbed retinal tissues."

Complications, Duration, Prognosis.—The complications of pernicious anæmia are rare—in fact, pneumonia, erysipelas, dysentery (Quincke, one case), nephritis, and local suppurations are the only ones that have been observed. Sequelæ are absent in those cases which get well, but the progress to full health is slow and fitful, and may be marked by serious relapses. The duration is variable. The average appears to be about five months. In some few instances the disease has terminated as early as six and eight weeks after its inception. The writer's fatal case was of three years' duration, dating from the first evidences of failure in health. Coupland found that 12 out of 110 cases were ill for periods extending beyond two years.

The prognosis is generally grave. A small proportion of cases get well. Pye-Smith analyzed 122 cases; of this number, 20 recovered. Two only of the 27 cases of primary essential anæmia collected by Eichhorst recovered. The elements that influence the prognosis are hard to establish. It had been thought that a diminution of corpuscles to 500,000 or under would render a prognosis unfavorable, yet one of Quincke's cases recovered, although there were but 143,000 red corpuscles per cubic millimetre. Quinquand determined that 26.5 gm. per 1,000 c.c., about one-fifth of the normal quantity, was as small an amount of hæmoglobin as was compatible with life. Yet here again Quincke's observations are at variance. He found in four cases the reduction to be one-eighth, one-tenth, one-fifteenth, and one thirty-fifth of the normal; the last was a case in which recovery took place. The prognosis is more grave under the following circumstances: first, when the disease occurs in a pregnant woman; second, when there are numerous syncopal attacks; third, when fever is marked and hemorrhages are profuse; and lastly, when cerebral symptoms, apoplexy, paralysis, etc., ensue. Labor pains in a pregnant woman affected with anæmia are the forerunner of death. Ehrlich considers the occurrence of numerous megaloblasts of bad prognostic omen.

Occasional remissions occur during the course of the disease, preceded by gastric crises and an increase of the erythroblasts. The number of red blood cells increases and may reach almost to the normal. The general symptoms improve simultaneously, but this is only temporary.

Diagnosis.—The recognition of this condition would be easy if there were some pathognomonic alteration in the blood. But most observers believe that there are no specific changes. Ehrlich, however, asserts with great positiveness that the presence of megaloblasts and numerous megalocytes is quite diagnostic. While this question is in doubt, the recognition of the disease must depend on a careful consideration of every available sign—the clinical picture, the blood picture, and the possible etiological factors.

Chlorosis is distinguished from pernicious anæmia with ease in most cases. The former disease occurs in girls near the age of puberty. The general condition is never so grave; retinal and cutaneous hemorrhages, and hemorrages from mucous membranes almost never occur. The "color index" of the blood is always less than normal, while in pernicious anæmia it is increased. Chlorosis is promptly relieved or cured by iron; this is an unfailing test.

Leukæmia is not likely to be confounded with perni-

cious anæmia if an examination of the blood is made. In leukæmia the white blood cells are enormously increased in numbers, while the leucocytosis of pernicious anæmia is never very great, the highest we are aware of being 30,000 per cubic millimetre. The spleen or the lymphatic glands are enlarged in leukæmia—conditions which do not obtain in pernicious anæmia.

Simple secondary anæmias, not pernicious in type, may sometimes reach an extreme degree. Their differentiation from pernicious anæmia is more difficult, but can usually be made on the basis of slighter degrees of blood changes and the more ready response to treatment. If megaloblasts are not present, the case is certainly not one of pernicious anæmia. Simple secondary anæmias are never more severe than the primary condition would seem to warrant, while a disproportionately severe anæmia is characteristic of the pernicious secondary type.

Pathogenesis.—This still remains obscure, although recent investigations have begun to shed some light on it. The etiological factors already spoken of are probably all in the nature of predisposing causes. The exciting cause is certainly something more profound. This is evident when we consider how commonly these predisposing factors are present, and yet how seldom pernicious anæmia occurs.

Three theories have been advanced to explain the development of the anæmia. They will be presented in the order of their plausibility.

The theory that is best supported by evidence is that which attributes the anæmia to excessive blood destruction (hæmolysis) caused by toxins absorbed from the gastro-intestinal tract. The anatomical and experimental evidence in favor of this view seems almost conclusive. Deposits of iron pigment in the liver, spleen, and other tissues were observed many years ago, but in 1889 Sir William Hunter made the observations significant by demonstrating experimentally that hæmolysis occurring in the general circulation gave rise to hæmoglobinuria, but that if it were produced in the portal circulation, excretion of urobilin and other iron pigments occurred, while many tissue cells, particularly of the liver, became infiltrated with iron pigment. The occurrence of urobilin in the urine and of iron pigment in the liver cells strongly suggests that in pernicious anæmia the hæmolysis occurs in some part of the portal circulation. The most likely cause of such hæmolysis is, of course, toxic products from the gastro-intestinal tract. The fever that occurs is an additional indication of toxæmia.

The other two theories advanced to explain this disease have less to support them. Stockman in 1895 suggested that minute capillary hemorrhages brought about by a simple anæmia so impoverish the blood that further fatty degeneration of small vessels occurs, causing additional hemorrhage. Thus a *circulus vitiosus* is established that leads from bad to worse until a fatal issue supervenes. The theory is one well worthy of consideration, but it is defective in not accounting for the influences that start the blood on its downward course in certain cases, while the majority of grave simple anæmias do not become pernicious.

The theory of defective hæmogenesis was based on the condition of the bone marrow. The marrow of the long bones reverts to the embryonal type and is undoubtedly engaged in active hæmogenesis. This is also indicated by the occurrence of nucleated red blood cells in the circulating blood. It was supposed that the red cells produced were turned out into the circulating blood in an immature and more vulnerable condition, and that on this account increased hæmolysis occurred. But the occurrence of identical changes in severe simple anæmias, not pernicious in type, and the absence of the change in certain cases of pernicious anæmia make it almost certain that the medullary changes are secondary to the changes in the blood, and not their cause.

A number of observers have described protozoan and bacterial parasites in the blood in pernicious anæmia, but their relationship is so doubtful that it does not seem worth while to give place to their discussion here.

Treatment.—Rest, massage, a liberal, nutritious, and easily digested dietary, the moderate use of stimulants, cheerful surroundings, and probably a change of scene are the chief non-medicinal means used for the restoration of health. Yet no definite results can be given of the beneficial effects of the above means, either singly or combined, unless it be of the last measure. One of Frerich's cases appeared to be cured by removal to a mountainous territory, while, on the other hand, one of the writer's cases improved at a city hospital, suffered relapse in his mountain home, and was completely cured on his second visit to the hospital.

The remedies commonly used in anæmia have been disappointing in this affection. Iron, phosphorus, cod-liver oil, quinine, and strychnine have failed as blood restorers or general tonics. Arsenic, however, has been found of inestimable service. Its value was first discovered by Bramwell, who used it first from a knowledge of its good effects in fatty degeneration of the heart.

Padley carefully considers the use of arsenic, and shows the results of treatment by this drug in 70 cases collected from various sources. Of the 70, 48 were treated without arsenic: 42 proved fatal, 2 were still under treatment, in 3 the result was unknown, and 1 recovered (authorities, Hobson, Coupland, Mackenzie, Bramwell, Barclay). Comparing this with the remarkable results derived from the use of arsenic, the most skeptical person will be convinced of its utility. Twenty-two cases were treated by arsenic; 16 recovered, 2 improved, and 4 were fatal (Coupland, Hobson, Bramwell, Finney, Broadbent, Withers, Moore, Lockie, and Padley). The drug should be given in small doses, gradually increasing until its physiological effects are produced. If gastric irritation is produced, hypodermic injections of arsenic in the form of Fowler's solution in five- to ten-drop doses may be employed. Transfusion has been employed with temporary relief in some instances; rarely has it been actually curative; four undoubted cases only are recorded by Pye-Smith as being cured. Quincke prefers arterial transfusion, others the venous. The transfusion may be done by the direct or by the indirect method. In addition to blood, milk has been used (Thomas, Pepper). It appears that a simple saline solution, used either subcutaneously or intravenously, as the urgency of the case demands, meets all the requirements, and is not by any means as dangerous as the use of the other liquids. Bone marrow has recently been introduced on the supposition that it would supply either red blood cells or an internal secretion supposed to be found in the bone marrow. The results obtained from its use are far from convincing, yet sufficiently good results have been reported to justify continued trials of the method, though it finds little support on theoretical grounds. Stengel recommends the use of "marrow jam," made by mixing in a mortar equal parts of red marrow from a calf and glycerin. From two to four drachms of this may be given three times a day.

Excellent results, and even cures, have been reported from the use of gastric lavage and colonic irrigation, together with intestinal antiseptic measures. Believing as we do, tentatively at least, that auto-intoxication from the gastro-intestinal tract is the cause of the disease, we judge these measures to be most rational.

Da Costa has benefited some cases by inhalation of oxygen. J. K. Mitchell, in experiments on the normal individual, showed that massage increased the number of corpuscles in the circulating peripheral blood. The effect was due, no doubt, to the dislodgment of corpuscles accumulated in small vessels and capillaries. Massage is therefore to be recommended in pernicious anæmia as a means of mobilizing the small army of stagnated corpuscles, in order to wage more effective war against the hæmolytic agent.

The symptomatic indications for treatment are generally met by the adoption of suitable measures. These indications are gastro-intestinal symptoms, the dyspnœa, the cardiac palpitation, and hemorrhages. The writer has seen very much benefit result from the use of caf-

feine for the cardiac debility, four grains being given at a dose, thrice daily.

It is to be regretted that we are compelled to add that often, in spite of the most careful hygienic and medicinal treatment, our efforts are in vain, and the disease progresses to a fatal termination.

For bibliographies the reader is referred to the previous edition of this work, to Coupland's article in Allbutt's "System of Medicine," and to the article of Ehrlich and Lazarus in Nothnagel's "Specielle Pathologie und Therapie." *John H. Musser.*
Frederick H. Howard.

ANÆMIA, SECONDARY.—Strictly, all anæmia must be considered secondary. It cannot be more than a symptom of some deeper cause, but there are certain types of anæmia in which we can form no idea of any underlying cause, and which, therefore, we designate as "primary anæmias." On the other hand, there are other cases of anæmia in which the symptom is clearly the result of some definite cause, such as hemorrhage, malaria, or tuberculosis. Such cases we designate as "secondary or symptomatic anæmia."

Anæmia, of whatever variety, consists in a deterioration of the blood with diminution either in the number of corpuscles per cubic millimetre, in the amount of hæmoglobin contained by individual corpuscles, or in a combination of both changes. The latter form is the commoner. Very possibly these changes in the number and quality of the corpuscles are all secondary to some change in the plasma, but this must be for the present largely a matter of hypothesis, as our knowledge of the changes in the plasma is still very limited.

Cases of secondary anæmia have been divided into the acute and the chronic.

Acute Anæmia.

The great majority of cases are, of course, due to hemorrhage, either through traumatism with obvious hemorrhage through the skin, or from rupture of the liver, spleen, or kidney. Among the other pathological conditions which are most apt to lead to severe spontaneous hemorrhage, we may mention the following list: (1) Abortion and the puerperium; (2) extra-uterine pregnancy; (3) tumors of the uterus; (4) the peptic ulcer, gastric or duodenal; (5) typhoid fever; (6) tuberculosis of the lungs; (7) epistaxis; (8) carcinoma of the stomach, intestine, or liver; (9) aneurism; (10) hemorrhagic pancreatitis.

It has been shown experimentally that the withdrawal of even 50 or 70 cm. of blood is enough to make an appreciable change in its quality. Hoffmann experimented upon a healthy man who had 5,219,000 red corpuscles per cubic millimetre, withdrawing 425 gm. of blood by venesection. Half an hour after, the red corpuscles were reduced to 4,762,000; one day later, they numbered 4,681,000. The amount of blood removed here was estimated to be about six per cent. of the total blood mass, supposing the weight of the blood to be one-thirteenth of that of the whole body. The fact that the blood shows more loss a day after a hemorrhage than half an hour after has been very often observed, and the difference is more marked the larger the amount of blood lost. This is undoubtedly due to the fact that the blood immediately after hemorrhage is unduly concentrated, whereas later on it is diluted again by fluid taken up from the surrounding tissues. As regards the amount of blood which an individual may lose without dying, observations differ a good deal. Behier records a case in which the red corpuscles were reduced to one-fifth their normal number after an attack of metrorrhagia, yet the patient recovered. Hayem describes the case of a woman who had, during six days following the puerperium, a number of severe hemorrhages. Fifteen hours after the second of these, the number of red corpuscles was reduced to 550,000, or eleven per cent. of the normal, yet the woman recovered. It has been repeatedly observed that women bear loss of blood better than men. It seems to be pretty well established that no animal can survive the loss of more than half its entire blood-mass at a single hemorrhage, but apparently men can stand a great deal more than this. [For the conditions obtaining during the regeneration after hemorrhage, see *Blood Formation.*]

Aside from cases due to hemorrhage we occasionally meet with what is practically an acute anæmia in cases of (1) Virulent septicæmia; (2) destruction of red corpuscles within the vessels as a result of poisons; for example, snake poison.

1. In cases of acute puerperal sepsis, I have known the red corpuscles to fall within a few days to 1,450,000 and the hæmoglobin twenty per cent. Grawitz* reports a case of acute puerperal sepsis in which the red cells were reduced to *300,000 within twenty-four hours!* This case seems almost incredible, but is related in great detail in Grawitz's recent text-book on "Diseases of the Blood."

2. Blood destruction as a result of poisons, such as chlorate of potash or nitrobenzol, may produce an acute anæmia, as happened in a case reported by Brandenburg: A woman who had taken two and one-half ounces of chlorate of potash the night before showed on the

First day, red cells	4,300,000
Second " "	2,500,000
Fourth " "	2,300,000
Fifth " "	2,100,000
Sixth " "	1,900,000
Seventh " "	1,600,000—death.

Symptomatology.—*The Blood.*—As regards the condition of the blood following hemorrhage, it has been already mentioned that the diminution in the number of corpuscles per cubic millimetre continues and increases for several days after the hemorrhage. After severe cases the lowest count is not reached until from five to seven days after the accident. While this process of deterioration is going on the hæmoglobin percentage always falls more rapidly than the count of red corpuscles, so that after the first twelve or twenty-four hours the color index is always low. Moreover, when regeneration begins, the hæmoglobin is always slower to reach the normal than the count of red corpuscles, so that the color index may even become lower, despite a distinct gain in both red corpuscles and hæmoglobin, because the latter gains so much more slowly. This is not in any way peculiar to acute anæmias, but is well exemplified in them.

In stained specimens normoblasts begin to be seen within from twenty-four to forty-eight hours of the time of the hemorrhage, or even sooner, and are continuously present in the peripheral circulation until blood regeneration is complete. As a rule they are scanty, and careful search is necessary to find them, unless the blood loss be very great and the regeneration very rapid. Occasionally they are so numerous as to appear in almost every field. Von Noorden was the first to observe that during the regeneration period a very large number of normoblasts may be suddenly discharged into the circulation within a few hours or days. This flood of normoblasts quickly ceases, and is then followed by marked increase in the total number of red cells. Such an appearance of large groups of normoblasts intermittently, and followed by a marked increase in the total count of red cells, has been named by Von Noorden a "blood crisis."

Atypical staining reactions in the red corpuscles (*polychromatophilia*) is often seen even within the first twenty-four hours after the hemorrhage. Careful measurements have shown that the red corpuscles undergo a *swelling* after hemorrhage, both their diameter and their thickness being increased. *Deformities* in size and shape are occasionally present, but not often marked. The *white corpuscles* show, in the majority of cases, an absolute or relative increase in the number of polymorphonuclear neutrophiles. This increase, as has been said, is not constant and may be of any degree up to very marked leuco-

* La médecine moderne, January 13, 1897.

cytosis. In rare cases, the leucocytes are diminished in gross, or the lymphocytes may be relatively or absolutely increased. Myelocytes in small percentages are not infrequently seen; indeed, in one of Ehrlich's cases six days after hemorrhage there was 13.7 per cent. of myelocytes with poikilocytosis and occasional normoblasts. Three days later the myelocytes disappeared.

The coagulability of the blood is increased and may take place twice or thrice as quickly as usual.

Other Symptoms.—Pallor of the skin, lips, and conjunctivæ, coolness of the extremities, a weak and tremulous voice, spots before the eyes, and noises in the ears, with dyspnœa, thirst, rapid, weak pulse, low temperature, and perhaps fainting, are to be observed even after hemorrhages of moderate severity. In severer cases there may be marked cerebral symptoms, aphasia, delirium, hallucinations, nausea, and vomiting, also cold sweat, increased secretion of urine, and tremor when movement is attempted. In fatal cases, one sees near the end of life the evidence of a great lack of fluid in the system, the skin becomes dry, the eyes lustreless; fibrillary twitchings or cramps may lead on to true convulsions. The temperature falls far below normal, and the pulse becomes almost imperceptible.

Albuminuria has been frequently observed associated with hyaline and granular casts within the first twenty-four hours after the hemorrhage. The urine is pale, and its daily amount increased, owing to the great thirst. A tendency to spontaneous bleeding is occasionally manifest in the gums or as a nose-bleed or uterine hemorrhage. The heart sounds are weak, often irregular, and frequently accompanied or replaced by murmurs, which are almost always systolic and loudest in the pulmonary area, though by no means confined thereto.

Besides the nervous symptoms already mentioned, neuralgia, especially of the cranial nerves, may be very obstinate. Amblyopia and amaurosis are occasionally observed. A certain amount of neuro-retinitis with occasional hemorrhages has been reported.

Post-Mortem Appearances.—(*a*) The most important change is fatty degeneration of the heart muscles, which may appear after hemorrhage even in cases which have proved fatal within a day or two, while if life had been prolonged a few days more, similar fatty change appears in the capillary system (especially in the brain), and in the secreting cells of the liver, stomach, and kidney. This fatty change is not to be explained, as was formerly supposed, by a diminished oxidation of the tissues, for all recent observations have shown that the oxidation processes are, if anything, increased in acute as in chronic anæmia.

(*b*) The bone marrow of the long bones undergoes, within a few days, a transformation in which the fat cells are replaced by enormous numbers of normoblasts, so that its color in gross is changed from yellow to red.

Diagnosis.—The diagnosis is doubtful only in cases of internal concealed bleeding. Under these circumstances it may be both difficult and important in cases of (1) Extra-uterine pregnancy with rupture; (2) internal hemorrhage, ante partum or post partum; (3) post-operative or secondary hemorrhage; (4) violent accidents involving "shock."

1. *Extra-Uterine Pregnancy.*—In cases of extra-uterine pregnancy, the diagnosis may be difficult before rupture occurs, but the symptoms of that event are very characteristic. Severe pelvic pain suddenly ceases, and then the patient begins to feel weak, restless, faint, and thirsty, and presents a pale skin and a weak, rising pulse. Such symptoms can only mean hemorrhage, and demand immediate operation.

2. *Internal Hemorrhage, Ante Partum or Post Partum.*—Any other concealed hemorrhage, such as may occur ante partum or post partum, shows its existence by the same symptoms. In case it is intra-uterine, an increase in the size of the organ can be made out by palpation and percussion.

3. *Post-Operative or Secondary Hemorrhage.*—Secondary hemorrhage after operation gives us the same symptoms and signs which have already been enumerated.

4. *Violent Accidents Involving "Shock."*—In cases of surgical shock, it is often important to determine how far the "shock" means anæmia from hemorrhage. If hemorrhage is going on, the worst thing we can do is to wait in the hope that time and stimulation will improve the condition, for time will, of course, make the matter constantly worse as the hemorrhage goes on. A blood count will often give us information of the utmost importance in such cases. Should it demonstrate the existence of a marked anæmia in a patient whom we have no reason to suppose previously anæmic, the diagnosis of internal hemorrhage is clear. I recently saw a little girl who had been run over in the street and was seen in a condition of what is often called "shock." There was no evidence of hemorrhage from any part of the skin or mucous membrane. A blood count showed a marked anæmia. A rapid laparotomy showed that hemorrhage was going on from a ruptured kidney. The hemorrhage was checked and the child recovered.

Treatment.—In the treatment of acute anæmia due to hemorrhage, when once the bleeding point is found and tied, the next thing is to restore to the depleted vessels an amount of fluid sufficient to keep up the heart action by giving it something to contract on. Transfusion of human blood has now given place to the introduction of normal salt solution, either subcutaneously, into the rectum, or into a vein. If the patient is unconscious, fluid may be infused subcutaneously with great ease and in considerable quantity. If the patient is conscious, this procedure gives considerably more pain than an intravenous injection. The introduction of salt solution into the rectum may be combined with either one or the other of these procedures.

Chronic Anæmia.

Among the commonest causes for chronic deterioration of the blood may be mentioned the following:

1. Repeated hemorrhages, such as occur in cases of gastric ulcer, menorrhagia or metrorrhagia, hemorrhoids, and hæmophilia.

2. Prolonged drain upon the albuminous materials of the blood, such as occurs in chronic dysentery, long-standing suppuration, phthisis, lactation, and cirrhosis of the liver with ascites.

3. Poisoning due to lead or arsenic, or in some less obvious way to toxic materials absorbed from the diseased gastro-enteric tract, or during the course of a case of nephritis. The fact is worth emphasizing that the anæmia which occurs in nephritis is due not to the drain of albumin out of the blood through the kidneys, but to a toxæmia. In chronic diffuse nephritis, for example, the amount of albumin lost through the kidneys is often trifling in comparison to the amount of anæmia. Probably under this same heading (*i.e.*, as a toxæmia) should be reckoned the anæmia occurring in connection with malignant disease. It is not simply starvation which brings about the deterioration of the blood, either in malignant disease or in other conditions in which the amount of food is insufficient, for it has been shown experimentally that starvation as such has no tendency to produce anæmia. After a forty-days' fast the blood of a professional faster has been found to contain more corpuscles per cubic millimetre than at the beginning of the fast.

4. Infectious diseases, especially malaria, syphilis, typhoid fever, acute articular rheumatism, and septicæmia due to pyogenic organisms, are apt to result in anæmia. We have already mentioned under the section on Acute Anæmia how grave a deterioration of the blood may occur in septicæmia. Tuberculosis rarely leads to any considerable degree of anæmia, unless a mixed infection with pyogenic organisms is engrafted upon the original disease, as indeed almost always occurs in pulmonary tuberculosis. Even here it is very surprising how little anæmia we often find, even though the

patient is deathly pale. In no other disease that I am acquainted with is there so little anæmia to be demonstrated in comparison with the degree of pallor. In this connection we may allude to the so-called tropical anæmia occurring in members of white races who have resided a long time in very hot climates, which has been shown to be no true anæmia at all, but only a blanching of the skin, due very possibly to the effect of the heat upon the circulation or upon the pigments of the skin.

5. The anæmias occurring in insanity are so frequent and so pronounced that the association of the two conditions can hardly be considered accidental, nor can the anæmia be explained as a result of taking too little food, for reasons given above.

6. Intestinal parasites may give rise to a very grave form of anæmia, either of the secondary type or in a form indistinguishable from primary pernicious anæmia.

SYMPTOMATOLOGY. — *The Blood.* — In some cases of anæmia the impression is often almost irresistible that the total amount of blood is reduced. We have no means of proving this, but hints are given by the difficulty of obtaining blood from a puncture of ordinary depth, and by the relative emptiness of the retinal vessels as seen by the ophthalmoscope. The color of the blood as it emerges from the point of puncture may be nearly normal in relatively mild cases, while in the severer grades of the disease it looks pale and watery or possibly particolored and streaky. This last appearance usually means an anæmia of the very severest type.

A good general idea of the severity of the case may be obtained by the estimation of hæmoglobin. The lowest percentages are seen in connection with malignant disease, acute septicæmia, and any affection involving profuse hemorrhage or suppuration. Readings as low as fourteen per cent. have been made by competent observers. It should be said, however, that in using the Fleischl hæmoglobinometer for percentages of twenty-five or less, the technique, as ordinarily carried out, gives us very faulty results. It is much safer, in any such case, to fill the capillary pipette of the instrument several times in succession, washing the contents each time into the same chamber of the cell in which the blood and water are mixed, and then after making the reading to divide the result by two or three, according as we have used two or three pipettes full of blood. The reduction in the amount of hæmoglobin is almost always out of proportion to the diminution in the number of corpuscles, that is, the individual corpuscles which are left contain less hæmoglobin per corpuscle than is normal. This condition is especially marked in the milder grades of the disease, and at such times the conditions may be exactly the same as those found in chlorosis; for example, one of Laache's cases of consumption showed 5,148,000 red corpuscles with only thirty-five per cent. of hæmoglobin. Similar figures are not infrequently to be recorded in anæmia secondary to malaria, malignant disease, or nephritis.

Red Corpuscles. As suggested in the last paragraph, the number of red corpuscles shows in the earlier stages of a case of secondary anæmia relatively little diminution despite a considerable falling off in the amount of hæmoglobin. If, however, the cause of the anæmia persists, for example, if the patient goes on having malarial chills, or if the nephritis or cancer be incurable, a considerable reduction in the number of red cells gradually makes itself evident, and may finally reach a figure as low as that characteristic of pernicious anæmia. The lowest count that I have come across is that recorded by von Limbeck—306,000. This case fully recovered. Counts of 1,500,000 or less are not at all infrequent in malaria.

The specific gravity of the blood runs practically parallel to the percentage of hæmoglobin, and the same is true of the amount of solid residue. The coagulability of the blood in secondary anæmia takes place considerably more rapidly than is normal. Hayem's pupil, Le Noble, who studied this subject extensively, has shown that in cases in which the number of blood corpuscles is less than 1,000,000 per cubic millimetre clotting takes place in about half the time occupied in normal cases.

Stained Specimens.—1. The pallor of the microscopical preparation in gross may be quite noticeable in severe cases, and in specimens stained with Ehrlich's triple stain it is not uncommon to notice in the mounted cover-glass preparation a bluish tint, instead of the orange-yellow color which we see in similarly mounted specimens of normal blood. I have observed this bluish tint more frequently in secondary than in primary anæmias. The blood is unusually easy to spread between cover glasses; excellent specimens may be prepared even by a beginner, who would have difficulty in handling normal blood. Under the microscope the most striking change is the sparseness with which the corpuscles are spread over the field and the pallor of the individual cells. This pallor does not affect the whole cell equally, but shows itself especially in the central portions, the rim or periphery of the cells being left relatively well stained, even when the centre of the corpuscles is colorless. The amount of "orange G" (of the triple stain) which the cell takes up corresponds very accurately with the amount of hæmoglobin which the cell contains. So far as we know, it is only the hæmoglobin which takes the stain. To the extreme form of this staining anomaly Litten formerly gave the name of "pessary-shaped" corpuscles, which were at one time supposed by him to be characteristic of pernicious anæmia, in which disease, as a matter of fact, they are rarely seen. Not every corpuscle shows equal changes in respect to its staining properties. Side by side with extremely pale cells one may see some relatively well-stained ones. This is especially the case in the relatively mild cases. Where the hæmoglobin is as low as twenty or thirty per cent., one rarely sees a single well stained corpuscle in the whole preparation, and there may be nothing but the "pessary shaped" cells to be found.

2. Normal red corpuscles have relatively slight affinity for basic stains and relatively strong affinity for acid stains In many anæmic conditions these staining affinities are so modified that some of the corpuscles take up both acid and basic stains, resulting in a diffuse coloration by a tint intermediate between those of the acid and the basic stain for example, a purple color in case eosin and methyl blue are used In other cases there appears, in specimens stained with Chenzinsky's solution, a spotted bluish pigmentation on a pink ground These irregular staining reactions may be seen even in relatively mild cases indeed, it is not always best seen where the hæmoglobin is lowest. Ehrlich still maintains that abnormal staining reactions, known technically as polychromatophilia, represent simply degenerative changes, but the weight of recent research has tended entirely in the opposite direction, and has proved to my satisfaction that polychromatophilic corpuscles represent immature forms which have been prematurely sent out from their place of manufacture, the marrow

3. Poikilocytosis Abnormalities in the size and shape of the corpuscles may be seen even in mild cases It is important to observe that the abnormalities in size consist in various degrees of diminution in the diameter of the corpuscles, and rarely, if ever, in an increase of their size. In the extreme cases almost all the red corpuscles may be undersized; some may be not more than 2 μ in diameter as compared with 7 μ, the normal size De formities of shape, even of the most extreme and bizarre description, may be met with in ordinary cases of secondary anæmia, and are in no way characteristic of any one type. Although a very great variety of shapes may be seen, there is a strong tendency to a repetition of certain irregularities The commonest of these are (*a*) Battledore shaped forms, (*b*) sausage shaped forms, (*c*) ovals (*d*) irregular triangles or quadrate forms

Quite active pseudo amœboid movements are not infrequently to be seen in the projecting points of deformed corpuscles or in the corpuscles as a whole. The central biconcavity may or may not remain visible.

4. Nucleated Red Corpuscles. In any form of secondary anæmia, especially in the severer grades, one may find nucleated red corpuscles, usually normoblasts. The number of normoblasts to be seen does not run parallel to the degree of anæmia, nor is any especial variety of anæmia particularly apt to show their presence, unless it is the post hemorrhagic cases. In the latter condition they appear in a relatively large percentage of cases, and apparently with a certain regularity; in the other forms of secondary anæmia their appearance and disappearance seem very arbitrary and unaccountable. Different cases of equal severity may differ very widely in the number of normoblasts seen, and even in the same case at different times one finds a very great variation; to-day there may be many of them, to-morrow none. Megaloblasts are not very infrequently to be observed in very severe cases, but never, so far as my experience of several thousand cases goes, do they preponderate over the number of normoblasts.

5. White Corpuscles. In certain varieties of secondary anæmia, for example, after hemorrhage, in suppurative diseases, and malignant neoplasms, one usually gets a considerable increase in the total number of white corpuscles, the increase being made up largely or wholly of the polymorphonuclear forms. In one case of cancer of the kidney I counted 92,500 white corpuscles per cubic millimetre, ninety-four per cent. of which were polymorphonuclear neutrophiles. On the other hand, there are many cases of very severe anæmia, such as those associated with nephritis or due to malaria, in which there is no leucocytosis or in which the leucocytes may be diminished. The eosinophiles are usually diminished whenever the polymorphonuclear neutrophiles are increased. In anæmias due to intestinal parasites the eosinophiles may be increased.

6. Blood Plates. After hemorrhage and in some other varieties of secondary anæmia the number of blood plates will be greatly increased. Van Emden,* in an anæmic child with splenic tumor, found 829,000 blood plates as against from 180,000 to 256,000, the normal number.

Other Symptoms.—(*a*) The effects of anæmia upon the central nervous system are shown in manifold ways, almost all of which, however, can be brought together under the title of "*irritable weakness.*" The neuro-muscular system is both irritable and weak, the irritability being shown in increased reflexes and a tendency to cramps and to "nervous," jerky, restless movements, while the weakness is shown in the great proneness to fatigue on slight exertion and the inaptitude in performing delicate movements requiring skill. Brain action likewise shows both irritability and weakness. There is little power for a continued attention or for self-control, and marked irritability and emotional abnormalities. Blurring or dark spots before the eyes and tinnitus aurium are common. Headache, vertigo, and fainting easily occur.

(*b*) The gastro-intestinal tract is easily irritated, as is shown by the frequent occurrence of hypersecretion and occasionally of diarrhœa, but it is also weak and unable oftentimes to perform its functions of digestion and peristalsis. It is hard to decide, however, whether these symptoms are truly the results of the anæmia or of the underlying cause of which the anæmia is symptomatic.

Appetite is almost always lost or very quickly appeased. Painful digestion, due to gastric hyperæsthesia or fermentation, is the rule. The amountof hæmoglobin is normal or increased in the great majority of cases, and the motor functions of the stomach are well performed. Despite the frequency of constipation there is usually no increase of intestinal fermentation, and the intestine seems to absorb normally.

(*c*) On the part of the respiratory tract we find usually superficial breathing, which easily becomes labored and frequent on slight exertion.

(*d*) The heart's action is weak, yet easily irritated to violent palpitation. Œdema of the extremities is common, and effusions into the serous cavities are seen occasionally in marked cases. Hemorrhage, presumably due to fatty changes in the vessel walls, is rare in acute cases, but not at all uncommon in chronic ones; it is usually small in extent, and affects the skin and mucous membranes, especially those of the mouth, stomach, and intestine. Hemorrhages are also common in the meninges and in the retina. Occasionally a considerable amount of blood may be lost by epistaxis or from the gastro-intestinal tract.

The urine shows no characteristic changes; it is oftentimes pale and of low specific gravity, and may contain a trace of albumin and an increase over the normal number of casts. The temperature may or may not be raised. An interesting point in this connection is the relation of temperature to temperament in acute post-hemorrhagic anæmia. After profuse gastric hemorrhage due to peptic ulcer I have twice seen continued fever (from 101° to 103° F.), lasting several days. Both these cases were in patients of markedly neurotic temperament. In the great majority of cases of post-hemorrhagic anæmia, in which there is no specially neurotic element, the temperature remains normal.

DIFFERENTIAL DIAGNOSIS.—1. Many cases are dubbed anæmic on the evidence of pallor of the skin, especially if this is associated with symptoms of general debility or neurasthenia. R. T. Edes and others have shown that neurasthenics are rarely anæmic, and it is important to recognize that pallor of the skin is consistent with perfectly normal blood and with good general health. The condition, therefore, most frequently mistaken for anæmia is probably neurasthenia and debility or a simple congenital pallor of the skin unassociated with any disease. Pallor of the mucous membranes, especially those of the lips and conjunctivæ, is a better test of anæmia, but not very infrequently we see considerable pallor of the mucous membranes, as well as of the skin, and yet no anæmia by blood examination. This is especially apt to be the case in pulmonary tuberculosis, in which we may find a normal or even an increased count of red corpuscles with extreme pallor of the skin and mucous membranes.

2. I have known myxœdema mistaken for simple anæmia with obesity and so treated. In both diseases we may have subnormal temperature, muscular and mental weakness, pallor, and œdema; indeed, the two diseases may, and often do, coexist, but simple anæmia does not cause the marked changes in facial expression and cutaneous nutrition, nor the peculiar mental hebetude and hestitating speech characteristic of myxœdema. In case of doubt, the therapeutic test, the use of thyroid extract, would easily decide.

3. Cases of incipient pulmonary tuberculosis, especially in the female sex, are not infrequently mistaken for simple anæmia or chlorosis. Only the most careful examination of the sputum and a most thorough auscultation of the apices of the lungs after cough will suffice to exclude tuberculous disease, which may exist entirely without cough or with so little cough that the patient's attention is not called to it. Any fever occurring in a case supposed to be simple anæmia should make us suspicious of tuberculosis.

4. Pernicious anæmia is at times difficult to distinguish from the symptomatic form of the disease. I have known some of the cases of anæmia secondary to gastric cancer or to chronic bleeding hemorrhoids in which only the blood examination made it possible to exclude pernicious anæmia. In the severest grades of secondary anæmia (which are those most likely to be mistaken for pernicious anæmia), we are very apt to have leucocytosis, a low color index, an absence of macrocytes, and a predominance of normoblasts over megaloblasts. There are, however, periods in the course of some cases of pernicious anæmia—namely, periods of remission—in which the blood may be indistinguishable from that of secondary anæmia. Earlier or later the typical blood picture appears, but for a time diagnosis may be impossible. I have twice mistaken cases first seen during this period

* "Bydragen tot de Kennis von het Bloed," Leyden, 1896.

for secondary anæmia. From chlorosis a case of secondary anæmia occurring in a young girl may be indistinguishable. The characteristics of the blood are identical, and if the etiology of the case is not clear there may be nothing to set us right.

PROGNOSIS AND COURSE.—The duration of the disease and the severity of the symptoms depend largely upon the nature of the underlying cause. In post-hemorrhagic anæmia, in which less than one per cent. of blood mass is lost, it should be made up in from two to five days; where from one to three per cent. of the blood mass is lost, it should be made up in from five to fourteen days; finally, in the severest hemorrhages, in which over three per cent. of the blood mass is lost, it may be a month or more before regeneration is complete. Young and well-nourished persons are naturally much quicker in making up losses than are feeble or elderly persons. Where the hemorrhage is secondary to such diseases as typhoid, phthisis, or cancer, regeneration after hemorrhage may be very slow, or may not take place at all. Bierfreund found that after operations for mammary cancer the hæmoglobin is much slower in beginning to rise toward normal than after operations for non-malignant diseases (a week later on the average), and he asserts that the hæmoglobin never reaches the point at which it was before. This statement is all the more extraordinary because Bierfreund has specially noted a gain in weight in the same patients on whose blood the above observations were made. In Bierfreund's experience, it is usually from twenty-three to twenty-seven days after operation on malignant tumors of the breast before the hæmoglobin begins to rise.

The improvement of cases of anæmia is likely to be interrupted by periods of relapse. This is not so true of secondary anæmia as it is of pernicious cases, but nevertheless holds to a certain extent.

TREATMENT.—Obviously the first and most important indication is to discover and, if possible, remove the cause to which the anæmia is secondary. Many cases will recover with no further treatment. As a rule, however, recovery is considerably hastened by therapeutic measures, and where the cause is unknown, as not unfrequently happens, we have to devote our attention to the following therapeutic agents.

Nutrition.—There is no especial diet appropriate to the treatment of anæmia; what is needed is a full and varied nutrition, which should certainly include red meat, owing to its relatively large proportion of hæmoglobin and so of iron. The digestion may need attention, but it is important to refrain from giving pepsin and hydrochloric acid in any case before we have made sure that there is not already a hypersecretion such as statistics show to be very frequent in anæmia. The bowels often need treatment either for diarrhœa or constipation, more especially the latter, and relief of this symptom will help the general nutrition, and so the anæmia.

Climatic change is undoubtedly of service in some cases, partly through its psychical and partly through its physical effect. Of late years it has been recommended that we send patients to high altitudes. Experience has shown that patients are very favorably affected by altitude, and the rapid increase in blood corpuscles per cubic millimetre which every person, sound or sick, shows in high altitudes appears to be not entirely transitory.

Medicinal treatment consists largely of proper administration of iron and arsenic. Wide experience in all parts of the world has shown that in the great majority of cases iron is best administered in the form of Blaud's pills. As a rule, they cause no irritation of the gastro-intestinal tract, and do not tend to constipation. I think it is a common mistake to use them in too small doses. To an adult I never give less than six five-grain pills a day, two after each meal, and after a week or ten days I often increase this to nine a day, three after each meal. In the rare cases in which Blaud's pills are not well borne or are not effectual in increasing the amount of hæmoglobin in the blood, it is advisable to try one of the newer organic preparations which contain hæmoglobin as such or some substance nearly allied to it; for example, ferratin. The only objection to these latter remedies is that in order to get sufficient quantity of them into the system to give an equivalent to six of Blaud's pills per day, or one-tenth of a gram of metallic iron, one has to spend a good deal of money. The tincture of chloride of iron should rarely, if ever, be given, on account of its strong tendency to produce constipation, its deleterious effects upon the teeth, and its very disagreeable taste. All preparations of iron should be given after meals, never upon an empty stomach. Occasionally arsenic is useful, especially in the severer grades of anæmia. It is best given in the form of Fowler's solution, two drops after meals, well diluted, and increasing one drop daily until the physiological limit is reached, as shown by the occurrence of itching or burning of the eyelids, nausea, or vomiting. *Richard C. Cabot.*

ANÆMIA, SPLENIC. See *Hodgkin's Disease.*

ANÆSTHESIA AND ANALGESIA.—Definition of terms: *Anæsthesia*, accurately speaking, denotes the loss of sense of touch. The term is often used to indicate the loss of all forms of sensibility—as pain, temperature, muscular location, etc. In this article, when the word is used without qualification, it shall mean the loss of tactile sense. Tactile sensibility is subserved by structures that take cognizance of change of contact, and are stimulated by motion of an external object in contact with the surface.

Analgesia is a term employed to denote the loss of sensibility to painful impressions.

Thermo-anæsthesia is a loss of temperature sense.

Ataxia is a symptom of loss of muscular sensibility.

"Muscular sense" is a complex affair, including several different forms of sensibility. There is the painful sensibility to traumatic impressions, to passive stretching and powerful contractions, as in cramps. The most characteristic "muscular sense," however, is that by which is determined the character of movements and postures due to muscular action, also the character of passive movements and postures of muscles at rest. It also includes the recognition of resistance to contraction, by which is estimated the difference in weight of objects; articular sense is included.

Methods of Testing Sensibility.—The determination of the varying degrees of anæsthesia and analgesia is made difficult by the fact that the physician must depend upon the statement of the patient for his information. The intelligence, attention, and sincere co-operation of the patient are necessary to secure reliable responses. Furthermore, individuals vary, within the limits of what is normal, quite appreciably in their sensibility to external irritation. Finally, in patients suffering from lesions which cause either a slight or perhaps a greater degree of loss of consciousness, sensibility is more or less diminished up to entire loss of sensation, even though the lesion may cause no anæsthesia directly.

In testing sensibility the patient should be blindfolded or in some other way prevented from seeing what is being done, in order that simulation or self-deception may be avoided. It is remarkable how vividly one can feel the prick of a pin or touch of a feather through the medium of sight. When the lesion is unilateral, a comparison of the two sides is very desirable. Various instruments of precision have been devised by neurologists for testing sensibility. These are convenient and desirable for scientific purposes, but for clinical use they are not essential. A much more important element is the cultivation of the judgment of the examiner by constantly using the same method of examination. No amount of paraphernalia will make up for a lack of that cultivation. A feather or camel's hair pencil or the tip of the finger may be used for testing tactile sensibility. The objection to the finger is the possibility that there may be a difference in temperature between the examiner's finger and the patient's skin, and consequently that contact may be recognized by temperature sense

even when anæsthesia exists. A common pin is a valuable instrument in testing for analgesia. By alternately using the point and head and requiring the patient to distinguish between them by saying "head" or "point," the physician can determine whether his answers are based on pain or tactile sense. When testing for anæsthesia the patient should be instructed to say "yes" each time he is touched; or he may be asked to name the point touched. This gives information as to his power of localization. If more definite information is desired, he may be asked to touch the exact spot that had been touched by the examiner.

On some accounts a better test for analgesia is to pick up a fold of skin and pinch the rounded portion. By practice one is enabled to determine quite satisfactorily the degree of sensibility by the degree of pressure required to produce a painful impression.

Thermo-anæsthesia may be present when tactile and pain sense are normal. To ascertain its existence one may employ two test tubes, one filled with hot and the other with cold water. More accurate means of measurement are needed for scientific record.

In the presence of a localized disturbance of sensibility the characteristics should be noted as accurately as possible. If there is an area of anæsthesia its boundaries should be definitely determined. The task is not difficult when the area is sharply defined, but it becomes more so when it passes gradually into the normal. Anæsthetic areas often exist without the patient's knowledge and will escape notice unless especially sought for. This should always be done in cases presenting obscure abnormal conditions of the nervous system.

For convenience of study the anæsthesias and analgesias may be divided into two great classes: I. Those of functional origin; II. those due to some organic lesion.

Functional Derangements of Sensibility.—I use the word functional advisedly and with a full knowledge and appreciation of the position of those who regard every derangement of function as evidence of organic lesion. I shall not argue this question further than to say that in the manifestations of the nervous system the evidence is convincing that temporary and more or less permanent suspension or derangement of function may and does occur without the existence of organic lesion.

Hysterical anæsthesia may involve all varieties of sensation. In such cases there will be no response to any kind of sensory stimulation—such as touch or pain or heat or cold or muscular action or change of posture or location of a part. Or the anæsthesia may be confined to one variety of sensation while the others may remain normal. Or again, any two or more of them may be involved. Analgesia is the form of anæsthesia most frequently observed in hysteria. Then follow, in order of frequency, loss of tactile sense, temperature sense, muscular sense, and articular sense. The last is quite rare as an hysterical manifestation, but has been noted by several observers. The physician should not assume that a case of ataxia is hysterical until he has discovered other stigmata and has excluded all other probable sources of ataxia. For further discussion of the stigmata of hysteria, see under *Hysteria*.

The anatomical distribution of anæsthesia, in hysteria, is extremely variable. No part of the body is free from the liability of a loss of sensibility from this cause. But it may conveniently be considered under three types: I. Hemianæsthesia; II. segmental; III. disseminated.

Hemianæsthesia is the most common type, and when present without motor disturbance it is most suggestive of hysteria. It involves exactly one-half the body vertically, the middle line, anteriorly and posteriorly, forming a distinct and abrupt line of demarcation between the normal and anæsthetic portions of the skin. The mucous membrane of the same side is also involved. Among the cases of hemianæsthesia from lesion of the posterior portion of the posterior limb of the internal capsule, there have been reported some which resembled those of hemianæsthesia of hysterical origin. These cases are so rare, however, as to be a curiosity.

In the segmental type of anæsthesia a hand and more or less of the arm, or a foot with more or less of the leg is anæsthetic—sometimes called the glove or stocking form of anæsthesia; or a part of the face or head may be involved.

In the disseminated type anæsthetic patches, irregular in size, shape, and distribution, occur. Any conceivable part of the surface may be the site of anæsthesia. I wish to call attention to three characteristic features of these anæsthetic areas, that should always be borne in mind when making a differential diagnosis: (1) The areas do not correspond to the distribution of nerves; (2) the borders are sharply outlined, the change to normal sensibility being abrupt, there being no gradual fading of one into the other; (3) the borders are not constant, but are subject to sudden changes. This feature has been especially emphasized by Dr. Patrick, of Chicago. This shiftiness of the borders is so pathognomonic that it should always be looked for in testing a case. A very soft pencil is needed to mark the outline so that no irritation of the skin is produced whereby the patient's subsequent replies may be influenced. I do not care to discuss the treatment of this condition, as it doubtless will receive proper consideration under *Hysteria*. But I may say in passing that the suggestiveness of the treatment is a most potent factor. Therefore the application of electricity to the anæsthetic area in the form of a powerful static spark or a strong galvanic current is among the most efficient of agents.

Any of the special senses may be involved in hysterical anæsthesia. We may thus have impairment or loss of sight, hearing, taste, or smell. Hysterical amblyopia most often consists in a concentric constriction of the visual field. Besides this there may be a disturbance of the color field, either a total loss of color perception or, what is more common, a reversal of the color fields; the most common form being that in which the field for red is larger than that for blue.

Pharyngeal anæsthesia is commonly due to hysterical disturbance of the function of the glosso-pharyngeal and vagus nerves, of which "globus" is another manifestation, and ageusia or loss of taste still another. Laryngeal anæsthesia is not an uncommon stigma of hysteria. The well-known tolerance of examination of the pharynx and larynx on the part of hysterical patients is due to anæsthesia of these parts.

Anæsthesia and Analgesia of Organic Origin. — In studying the organic lesions of the nervous system with their consequent impairment or loss of sensation, we cannot do better than to adopt an anatomical classification. We shall consider: 1. Lesions of peripheral nerves; 2. lesions of the cord; 3. intracranial lesions.

Trigeminal anæsthesia, more or less complete, results from a destructive lesion in any portion of the nerve from its central origin to its peripheral terminations. The location of the lesion may be determined by the extent and distribution of the anæsthesia, and—in the case of a lesion located at the base of the brain—by noting the disordered function of other nerves involved in this lesion. Peripheral lesions are indicated by the small portion of the nerve involved. If a portion of the face with a corresponding mucous surface is involved, one branch of the nerve is affected at or near its exit from the cranium. If the anæsthetic area comprises the distribution of an entire nerve and is complicated by trophic disturbances, the lesion is in the Gasserian ganglion or its immediate vicinity. A lesion in the posterior portion of the posterior limb of the internal capsule will produce anæsthesia of one side of the face and of the same side of the body, resembling hysterical hemianæsthesia (to which the reader is referred). If one side of the face and the opposite side of the body are anæsthetic, the lesion is probably pontile.

The pathological diagnosis is made by considering the history and development of the abnormal condition. Among the more important factors to be considered are

neuritis from syphilitic, rheumatic, toxæmic, alcoholic, or other origin; tumors at the base of the brain; basal meningitis; traumatism, either peripheral or central. Trigeminal anæsthesia may be the initial symptom of some chronic degenerative disease, such as tabes, chronic muscular atrophy, syringomyelia, etc. In such cases, however, if the attention has been called to that possibility, upon closer examination there will be found other symptoms that will lead to a correct diagnosis. A destructive lesion of the tubercle of Rolando of one side causes a complete loss of all forms of sensibility of the trigeminus of the same side as the lesion, with anæsthesia of the body and limbs of the same side and analgesia of the opposite side. There are motor disturbances accompanying this lesion to which attention will be called farther on, under *Hemianæsthesia*.

Glosso-Pharyngeal Anæsthesia. — In focal destructive lesions of the glosso-pharyngeal nerve, anæsthesia is produced in the region of distribution of its fibres of common sensibility, viz., in the upper part of the pharynx and in the upper portion of the palate. This occurs most frequently in connection with paralysis following infectious diseases, such as diphtheria, but the anæsthesia is seldom limited to the parts supposed to be supplied by the sensory portion of the glosso-pharyngeal nerve.

Pneumogastric Anæsthesia.—The branches of the vagi in which destructive focal lesions give rise to the most noticeable anæsthetic conditions, are the superior laryngeal and the gastric. Laryngeal anæsthesia as an independent condition is caused by focal lesions in the sensory branches of the superior laryngeal nerve. It may be one of the symptoms of degeneration of the laryngeal portion of the vagus nucleus, as in tabes. In post-diphtheritic conditions laryngeal anæsthesia is due, most probably, to the action of toxins upon the nerve in its course, terminations, or centres

The symptoms of laryngeal anæsthesia are such as result from the anæsthesia. The absence of reflex coughing and the consequent retention of mucus and other foreign matter give rise to inflammatory conditions and consequences, and upon examination abnormal tolerance of manipulation will be found to exist.

Gastric Anæsthesia.—This results from some lesion in the gastric branches of the vagus, on account of which sensory impulses are not transmitted from the stomach to the cerebrum. In this condition immoderate quantities of food are required to appease hunger, and in total anæsthesia the feeling of repletion is never experienced.

The treatment of the anæsthesia of the vagus is best accomplished by the use of electricity, to be applied to the seat of the anæsthesia if within reach. Tonics, alteratives, and eliminatives, as indicated by the nature of the malady upon which the anæsthesia depends, should also be administered. Among the causative agents may be mentioned syphilis, alcoholism, arsenic, lead, various toxæmias, auto-intoxication, and degenerative conditions, such as tabes. If a tumor presses upon the nerve, of course the condition will be relieved only by removal of the pressure.

While anæsthesia and analgesia may occur in the distribution of the sensory branches of any of the spinal nerves, it will not be profitable to consider each in detail. I shall confine my attention to two regions: the region supplied by the brachial plexus and that supplied by the lumbar and sacral plexuses. Disturbance of the function of the nerves in these two regions is more conspicuous than that of any other region supplied by spinal nerves, by reason of the importance of the parts involved. Furthermore, their exposed position and constant use render them more liable to attacks of disease and to traumatic injuries. This remark has reference only to peripheral lesions. To determine whether the lesion is peripheral or central requires close attention to the distribution of the anæsthesia, to the history of the case, and to the mode of development of the attack.

Anæsthesia or analgesia, or both, will not infrequently be found among the symptoms of peripheral neuritis, both multiple and single. Hence, in searching for a pathological diagnosis in a given case of anæsthesia, the same pathological factors should be taken into account as in peripheral neuritis and motor palsy. Anæsthesia over the scapula is a result of disease of the suprascapular branch of the brachial plexus. The circumflex supplies the deltoid and the skin over the muscle. A lesion of this nerve may cause anæsthesia over the lower part of the deltoid. Anæsthesia of the radial side of the forearm points to a lesion of the musculo-cutaneous nerve. Lesion of the musculo-spiral nerve is very common, but the anæsthesia is very inconstant, and may involve the radial side of the hand, the back of the thumb, the index finger, and one-half of the middle finger.

Median nerve disease may cause loss of sensation on the radial side of the palm and front of the thumb, of the first two fingers and of one-half of the third finger. The backs of the distal phalanges of the thumb and first two front fingers may also be anæsthetic. The ulnar nerve subserves sensation on the ulnar side of the hand, back and front, two and one-half fingers on the back, and one and one-half in front. In lesions of the nerve anæsthesia may be present in those areas. Loss of sensation of the entire brachial plexus would point to a cord lesion, except in brachial neuritis, when other symptoms would lead to a correct diagnosis.

Sciatic neuritis, while usually a very painful affection, may give rise to loss of sensation in the cutaneous distribution of the sciatic nerve. To illustrate: a lady sixty years old came to my office complaining of a dead feeling in her right lower limb. Examination showed cutaneous analgesia in the entire distribution of the sciatic nerve, also thermo-anæsthesia in the same region. Tactile sense normal, reflexes subnormal; muscular and articular sense normal, co-ordination normal; muscle tension exaggerated. The history showed that three weeks previously the patient had suffered from tingling, cramping, burning pain which prevented her from using the limb. Putting the muscles on a sudden stretch still caused muscular pain. The sallow, muddy complexion, vile breath, swollen, coated tongue, tympanitic and constipated bowels led me to make a diagnosis of sciatic neuritis from gastro-intestinal auto-intoxication. Free elimination and correction of the gastro-intestinal fermentation caused rapid improvement in the condition of the limb. I am convinced from this and many other similar cases that a degenerative neuritis may involve one or more kinds of sensory fibres of a nerve, while the other fibres remain practically intact. The causative factors are a general poison with local vulnerability.

Anæsthesia of the outer lower part of the back of the leg is caused by a lesion of the internal popliteal. With lesions of the external popliteal there is anæsthesia on the outer half of the front of the leg, and on the dorsum of the foot.

Plantar anæsthesia is occasionally caused by plantar sciatica. If the internal plantar nerve is involved, the anæsthesia will be on the inner part of the sole and plantar surface of the three inner toes and one-half the fourth. If the external plantar is the nerve involved there will be anæsthesia of the remaining outer part of the plantar surface.

In Raynaud's Disease.—Slight anæsthesia and numbness occur in the beginning of this disease, and in mild cases it is more or less constant. In severe cases the anæsthesia is replaced by severe pain. It begins in one or more fingers of each hand and spreads. The toes are similarly affected, and so also are sometimes the tip of the nose and the ears.

The pathological conditions which give rise to loss of sensibility in peripheral nerves are numerous and varied, and include systemic or blood states as well as local conditions. Among the former may be mentioned various toxæmic conditions, such as malarial intoxication, uræmia, auto-intoxication from gastro-intestinal fermentation, and the different toxinæmias induced by the infectious diseases—diphtheria and typhoid or typhus fever. Drug intoxication also plays a part. Among

the drugs to be thought of, alcohol, arsenic, and lead are most prominent. Among city patients, especially females, excessive tea drinking is not an uncommon factor. In fact any condition that is capable of producing deterioration of structure or derangement of function is liable to cause disturbance of peripheral sensibility in the form of the various anæsthesiæ. Among the local causes may be mentioned various forms of traumatism, as blows that suddenly interrupt the conducting power of the nerve, or persistent pressure, or prolonged stretching, as occurs in the ulner nerve when sleeping with the elbow sharply flexed. Neuromata in the course of the nerve, neoplasms in the immediate vicinity of the nerve trunk, enlarged glands pressing upon it, exostoses, inflammatory adhesions or cicatricial bands constricting or binding it down, may impair or abolish its function.

Lesions Involving the Spinal Cord.—Loss of sensation as a symptom has a greater importance in disease of the spinal cord than in any other relation. It is a very common symptom of spinal-cord lesion, and may result from disease of any part of the sensory path or from a lesion of some contiguous structure by which pressure may be produced upon the part of the cord whose function it is to transmit sensory impressions.

The loss of sensation may be total or partial; it may involve all forms of sensibility, or may affect some forms and not others. This depends chiefly upon the fact that different parts of the sensory path serve for the transmission of different forms of sensibility. It may be due less often to a difference in the vulnerability of the different kinds of fibres. Loss of different forms of sensibility may be of more value in the future, as a means of localizing the seat of the disease, than it now is; for then we may have ascertained more accurately the path for each form of sensibility. At present our knowledge is too uncertain to base positive opinions upon. Furthermore, it is not improbable that the paths for sensory impulses are not as constant in their location nor as compact in their formation as are the motor tracts. There is very strong evidence, however, that pain and temperature sensation are transmitted by the antero-lateral tracts. In syringomyelia involving these tracts we are likely to have analgesia and thermo-anæsthesia, while tactile sense remains unimpaired.

It is sometimes difficult to determine whether the loss of sensation in a given case is due to cord disease or disease of the posterior nerve roots. If the lesion be in the nerve roots, the reflexes in the anæsthetic area will be abolished. If the cord alone be involved in the lesion, the reflex arc will not be broken and reflexes will remain intact. It may happen that a lesion of the cord is so situated as to involve the posterior roots within the cord. In such a case the reflexes would be abolished at the level of the lesion, but would remain intact below that level. This makes it necessary to test at the level of the lesion as well as below it. That level may be on the trunk or limbs. In trying to determine whether a lesion is peripheral or in the cord it is well to remember that as a rule cord lesions are bilateral, while peripheral lesions are unilateral. Multiple neuritis is an exception to the rule, and exceptions to the former will occur. Disease of the nerve roots outside the cord usually involves all forms of sensibility, unless the damage is very slight, when tactile impressions may be arrested and not the more energetic pain sense. Damage to the cord is more likely to impair one form without the others. Temperature sense is not impaired without the pain sense.

Among the lesions in which loss of sensation is a prominent symptom, we may mention meningeal hemorrhage, locomoter ataxia, myelitis, syringomyelia, etc.

By the courtesy of Dr. J. V. Lesnet, of Montpelier, Ohio, I was called to see Mr. S., a teamster by vocation, a strong, muscular, thick-set man about forty years of age. Early in the afternoon, while on his way to the woods for logs, he stopped by the roadside to heed a "call of nature." While in the act of defecation he suddenly gave a cry of pain, and fell over unconscious. He was picked up by his fellow-workmen and brought to his home in the village, and the doctor was called. He soon regained consciousness, when it was found that total anæsthesia and analgesia existed from the lower part of the neck, on a level with the clavicle, down. Motor power and muscle sense were not impaired. He complained of pain in the back of the neck; otherwise he felt well. A diagnosis of meningeal hemorrhage of the posterior portion of the cervical cord was ventured. Aconite was exhibited internally. A saline cathartic was administered and cold applications were made to the back of the neck. There was no interference with the normal action of the rectum or bladder. The patient improved rapidly and recovered completely; in a few weeks he was able to resume his work.

In degenerative diseases of the cord, involving the sensory tracts, some one form of sensation is likely to be impaired earlier and more completely than the others. As I have intimated before, this is probably owing to a greater vulnerability of the parts involved, for some local reason.

In locomotor ataxia anæsthesia of the soles of the feet is often more obtrusive and is noticed earlier by the patient than the ataxy. A patient complaining of this symptom should be examined as to his myotatic irritability, co-ordination, pupillary reflex, and other signs of tabes. An earlier diagnosis than is usual may thus be made.

Anæsthesia occurs in the course of spinal meningitis, but it is usually preceded by hyperalgesia. The anæsthesia is only of importance when considered in connection with other symptoms.

Sensory disturbances are among the more obtrusive symptoms in transverse myelitis. Anæsthesia may come on before, or at the same time as, the motor disturbance. All forms of sensation are impaired to a greater or less degree. Vesical and rectal anæsthesia exist, on account of which retention of urine and constipation occur. These symptoms being observed will call attention to other features by which a diagnosis will be made.

Tumors of the cord or its envelope will cause loss of sensation if they are located in the sensory tract or encroach upon it so as to interfere with its function. Aside from traumatic injuries tumors are the most frequent cause of unilateral anæsthesia. In any case of unilateral anæsthesia of obscure origin the possibility of a tumor should be thought of. The form of anæsthesia will depend upon the portion of the sensory tract involved. In this connection the word tumor is used not in its pathological sense, but in its etymological sense of swelling. Thus, the tumor may be an aneurism, a tuberculous deposit, etc.

The sensory fibres cross to the opposite side of the cord soon after their entrance into the cord. A unilateral injury to the cord will consequently give rise to a loss of sensation in the side of the body opposite the lesion. A brakeman on a Lake Shore train was knocked from his train while passing under a viaduct in the city of Detroit. He was brought to Emergency Hospital in an unconscious condition and placed under Dr. Hal C. Wyman's care. Examination showed crushing of the right side of the fifth cervical vertebra. The neck was extended and suitably supported in position. When the patient regained consciousness, anæsthesia and analgesia of the left side of the body and palsy of the right side were found to exist from the neck down. Exaggerated knee jerk and ankle clonus were found on the right side. Skin reflexes were exaggerated on the left side. The patient recovered with anchylosis of the injured vertebra. He gradually progressed toward the normal, so that in about two years he was able to resume his occupation.

Anæsthesia from Intracranial Lesion.—In discussing the sensory pathway in the spinal cord reference was made to the somewhat uncertain condition of our knowledge of its boundaries. In a general way the posterior columns are concerned in the transmission of sensory impressions, but the antero-lateral columns are also concerned in the transmission of certain varieties of sensation. Our knowledge of the intracranial sensory pathway is

still more uncertain. Between the upper end of the spinal cord and the internal capsule the path has not been definitely located. It probably passes up in the posterior half of the medulla and pons, beneath the corpora quadrigemina, through the tegmentum of the crus cerebri, and passes into the internal capsule, where its position has been accurately determined. As may have been inferred from the remarks on the loss of sensation in the fifth nerve with anæsthesia on the same side of the body caused by a lesion in the internal capsule, the sensory path occupies the posterior third of the posterior limb of the capsule. As the path from the fifth nerve joins it in the upper part of the pons, the posterior part of the capsule transmits sensation from the entire opposite half of the body and head, skin, and mucous membranes. Furthermore, the path of special sensibility from the organs of special sense—vision, hearing, taste, and smell —here lie contiguous to the path of cutaneous sensibility. In the case of vision we must remember that there is not a complete decussation of fibres at the optic chiasm; consequently the half of the field of vision of each eye corresponding to the side from which the other sensory impressions come, is represented in the sensory path. This is of diagnostic importance and will be referred to again.

The final distribution of the sensory path in the cortex is also a matter of some doubt. The sensory fibres pass into the white substance of the central hemisphere and go toward the region covered by the parietal bone and to the quadrate lobe and gyrus fornicatus of the mesial surface of the cerebrum. Much discussion has been had and is still going on as to whether the central (motor) area of the cortex is also a sensory area. A destructive lesion in the motor area causing paralysis also causes more or less anæsthesia of the palsied side. The loss of sensation, however, is not co-extensive with the palsy; neither is it permanent nor so persistent. This, with other facts, leads to the opinion that the motor area subserves sensation not directly from projection of the fibres from the path for cutaneous sensibility, but by commissural fibres.

Hemiplegia may exist without any sensory loss or with every degree of it. Hemianæsthesia may exist alone or in connection with every degree of paralysis up to complete hemiplegia. It is unusual for both to exist in a high degree.

Hemianæsthesia may involve all forms of sensibility, or some more than others. In its complete form it involves one vertical half of the body, including mucous membranes. It is always the result of a lesion in the path; for a cortical lesion, to produce hemianæsthesia, would need to involve so much of the cortex that the disturbance of other functions would overshadow the anæsthesia. If the lesion is in the pons, the parts supplied by the fifth nerve escape. Hence the anæsthesia does not involve the face and head. The most frequent location of a lesion causing hemianæsthesia is in the posterior part of the internal capsule. As was said before, a lesion in this locality causes complete hemianæsthesia and involves at the same time the nerves of special sense. This bears a strong resemblance to hysterical hemianæsthesia. In the latter, however, one-sided amblyopia is most likely to occur, while in the former hemianopsia will result; that is, one-half of each field of vision corresponding to the anæsthetic side will be interrupted. When discussing trigeminal anæsthesia I said that the destruction of the tubercle of Rolando causes loss of all forms of sensibility in the distribution of the fifth nerve, and loss of tactile sense in the body and limbs of the side of the lesion and analgesia of the opposite side. The motor disturbances comprise changes in the pupil, narrowing of the palpebral fissure, lessened prominence of the eyeball on the same side, and paresis of the arm and leg on the opposite side.

Cortical lesions can produce hemianæsthesia only when they are very extensive. The special senses may be involved, but instead of hemianopsia there will be loss of sight in the eye on the anæsthetic side.

Hemianæsthesia with hemiplegia and third-nerve palsy of the same side as the lesion is evidence of lesion of the crus.

Tumors in the cerebral hemispheres are likely to cause more or less loss of sensation, in combination with other symptoms, according to what portion of the cerebrum is involved.

Hemianæsthesia involving all forms of sensation may occur in connection with motor disturbance if the tumor is located in the central area of the cortex. Tumors of the parietal region produce disturbance of the muscular sense as their most characteristic symptom, together with hemianæsthesia. Motor disturbances will occur if the tumor encroaches upon the motor area. In the occipital lobes tumors produce hemianæsthesia if they encroach upon the parietal lobes. Disturbances of special sense, particularly sight and hearing, will also occur.

The study of the sensory, as well as the motor disturbances, is of value simply because it enables one to localize the causes of the symptoms. This is more useful from a surgical than from a medical standpoint. For a pathological diagnosis we must rely upon the history of the case, its mode of development, and concurrent conditions. Any destructive lesion involving the sensory path or cortical distribution will cause a greater or less degree of anæsthesia. Among these may be mentioned tumors, gummata, aneurisms, embolism, thrombosis, hemorrhage, and various degenerative and inflammatory processes. Consideration of these will be found under the appropriate heads. *Joseph A. Weitz.*

ANÆSTHESIA, LOCAL (SURGICAL).—Local anæsthesia, or better, local *analgesia*, became possible when the properties of cocaine were discovered by Koller in 1884. Previous to that time it was known that an area of the skin could be benumbed by cold or by depriving it for a time of its blood supply. But the anæsthetic effect of local anæmia could be obtained only in an extremity, while the chilling or even the freezing of the skin by means of a spray of ether had only a limited application. Koller discovered that a strong solution of cocaine, if applied to a mucous membrane for a few minutes, will make it insensitive to pain. By experiments he proved that a solution of cocaine injected into the tissues has the same effect. This discovery opened a wide field for the surgeon, as many trivial operations could now be painlessly and easily performed without the expense, discomfort, and danger attending the use of a general anæsthetic.

Fifteen years' experience with cocaine has fully justified the claims of its discoverer for its analgesic powers. Experience has shown, however, that it is by no means the harmless drug which its early advocates supposed it to be. Medical literature has recorded a long list of accidents from its use, many of them followed by a fatal result; while, far more frequently, alarming symptoms have developed, which fortunately have subsided after prompt action on the part of the surgeon. There is probably no surgeon of experience who has not met with one or more accidents of this character.

The idea uppermost in the mind of those who early employed cocaine to minimize the pain in operations, was to use a solution strong enough to accomplish this end with certainty. Hence solutions containing five per cent., ten per cent., or even twenty per cent. of the drug were swabbed or sprayed upon mucous surfaces or injected into the tissues. The appearance of toxic symptoms in certain patients impressed upon the minds of careful men the necessity for a change in the method of administration in vogue. As a result, some experimenters began to employ weaker and weaker solutions of cocaine, while others hunted through chemical laboratories for some substance less poisonous than cocaine, with equal analgesic powers, and still others attempted to develop the possibilities of analgesia by cold.

A suitable fluid was found in ethyl chloride. For convenience it is put up in tubes having at either end a minute opening closed with a screw cap. If the tube is held in the hand, a portion of its contents is vaporized

and exerts a pressure within the tube. Hence, if the lower cap is removed, a fine jet of fluid is forced out of the tube and may be sprayed upon the skin. In a few moments whitish spots will appear wherever the cold produced by evaporation is sufficiently intense to freeze the water contained in the skin. This method of obtaining analgesia has been employed in France more than elsewhere. It is most serviceable in benumbing the skin previous to inserting a needle for aspiration, or for tapping hydrocele, or in opening an abscess. From the nature of the case it is unsatisfactory in surgical operations requiring dissection of the tissue. The power of ethyl chloride is not sufficiently great to penetrate deeply, and even if it were, the risk of injury would deter the surgeon from keeping a tissue frozen for any length of time. Moreover, the reaction, when the blood again courses through the part, is often an extremely painful one.

Still other surgeons have followed up the effect of local anæmia in reducing sensitiveness. This method is especially applicable to the hand and forearm. They found that if the blood is pressed from the hand and arm, and the tourniquet applied with sufficient force to prevent any fresh blood from entering, sensation is pretty nearly suspended after a lapse of ten or fifteen minutes. This method of operating deserves wider notice than it has received. It has proved a valuable adjunct to a chemically produced analgesia, since the amount of the reagent needed to deaden pain is far less if the circulation of blood is controlled in this manner. The limb is first stripped of its contained blood by the application of Esmarch's bandage from the finger tips to the middle of the upper arm, each turn of the spiral overlapping the turn below by about half an inch. This enables the surgeon to unwind the bandage from the fingers up, and before the turns above the elbow are removed, the tourniquet should be applied, or the upper turns themselves may be left to act as a tourniquet. Attempts have also been made to render bloodless a part of the lower extremity, or an area of the scalp, or of the cheek, etc., by pressure exerted through variously shaped rings. Anæmia in the regions mentioned is more difficult to obtain, and is, on the whole, less satisfactory than that obtained in the extremities, as above described.

The efforts of other investigators to improve chemical analgesia have been very successful. It was early discovered that a solution of cocaine, even though far less concentrated than those originally employed, is still entirely satisfactory. The credit of enforcing this fact upon the medical world is due especially to a French surgeon, Reclus, and a German surgeon, Schleich.

Reclus advocated the use of a one-per-cent. solution of cocaine, or, in certain cases, of a two-per-cent. solution. Solutions of a greater strength he never employs, claiming that they are unnecessary and dangerous. As long ago as 1893 he published a report of two thousand operations performed in complete analgesia brought about by these weak solutions of cocaine. In no instance was there a fatal accident, nor even any bad symptoms.

Schleich performed a great number of experiments to determine exactly how weak a cocaine solution can be without losing its analgesic powers. His experiments led him to several important conclusions. In the first place, they showed that a solution of cocaine as dilute as 1:5,000 is possessed of analgesic power, although the quantity of fluid injected under such circumstances must be far greater than that injected if the solution contains a high percentage of cocaine. The question now raised in his mind was this: Does not the water, by distention of the tissues, reduce the sensitiveness of the nerves, either by pressure upon them or secondarily through a local anæmia? Further experiments showed that this supposition was partially true, and that pure water injected in considerable quantity has the power of reducing the sensitiveness of the parts. The injection of pure water is, however, very painful. He next tried the effects of the injection of normal salt solution, 0.6 per cent. This causes no pain, but its analgesic effect is practically *nil*. A weaker solution of salt, 0.2 per cent., proved more serviceable. The injection of this solution produces little pain and brings about a slight analgesia. Using this, then, as a vehicle, he dissolved cocaine in sufficient quantity to make a solution of one part in a thousand. To this mixture he added a minute quantity of morphine, believing that the analgesic effect of the cocaine was thereby prolonged. Since the injection of large quantities of fluid in an inflamed area causes great pain, Schleich employs under such conditions a somewhat stronger solution of cocaine, so that a less quantity of fluid may be injected. Indeed, he recommends the preparation of solutions of three different strengths, the formulæ for which are as follows:

	Sol. I.	Sol. II.	Sol. III.
Cocaini hydrochlorici	0.2	0.1	0.01
Morphinæ hydrochlorici	0.025	0.025	0.005
Natr. chlorat. sterilisat	0.2	0.2	0.2
Aquæ destill. sterilisat	ad 100.0	100.0	100.0
Adde acid. carbol. (five per cent.)....	gtt. 2	gtt. 2	gtt. 2

Solution I. for hyperæsthetic areas (inflammation, suppuration, neuralgia).
Solution II. for moderately hyperæsthetic areas.
Solution III., for extensive operations, to be used alternately with the more concentrated solutions.
For general work Schleich advises the use of Solution II., or the "normal" solution as he calls it.

Schleich also insisted upon a particular method of injection. To render the skin insensitive, the hypodermic needle should be thrust into it nearly parallel to the surface, and not through it. Slow pressure upon the piston will force the fluid into the meshes of the skin, distending them and causing a white wheal to appear. The needle should then be withdrawn and reinserted in the edge of this insensitive wheal, and a second injection made in the same manner as the first. A second wheal is thus produced beyond the first one, in the farther edge of which the needle is again inserted for a third injection. This process is repeated until the benumbed area extends throughout the line of the proposed incision (Fig. 195).

If an abscess is to be opened, or any operation performed which requires cutting beneath the level of the skin, the series of infiltrated areas is made to extend not only across the skin surface, but also in a semicircle beneath the abscess or tumor (Fig. 196). For this purpose a long slim needle is required, and each succeeding injection is made by pushing the point of the needle a little farther under the abscess or tumor. A curved hypodermic needle answers admirably for this purpose. When half

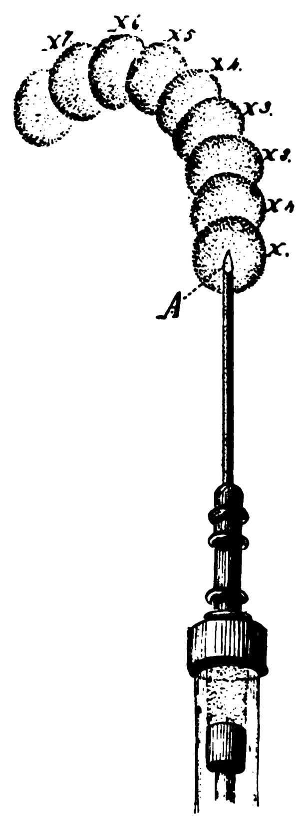

FIG. 195.—Showing Injection Along a Line of Incision in Skin. X, X^1, X^2, etc., first, second, third, etc., points of injection. After the first puncture, A, the needle is always inserted in the edge of the area last anæsthetized. (From Schleich.)

of the required distance has been traversed, the needle is withdrawn and inserted from the other side. In this manner even a deep incision or dissection can be made in perfectly benumbed tissues (Fig. 197).

Injections of every character into skin already tense from contained exudation are extremely painful from the additional stretching of the tissues which they produce. On this account, if the abscess to be opened lies in the skin or so close to it that the skin has become

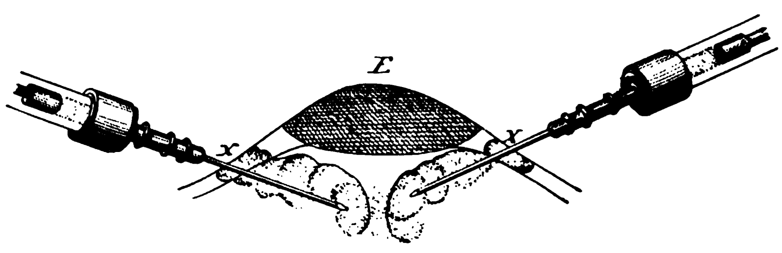

FIG. 196.—Showing Injection Below Abscess Near Surface of the Skin. *E*, Abscess; *X*, *X*, points of injection. (From Schleich.)

tight over it, the pain can be greatly lessened by puncturing the most prominent point of the abscess with a sharp, narrow-bladed knife. A portion of the pus will then flow out, relaxing the tissues so that the whole tract to be incised can be painlessly filled with the cocaine solution. This preliminary puncture can be rendered painless by the ethyl-chloride spray, or a drop of cocaine may be inserted in the skin at this point.

Schleich deserves a great deal of credit for his service in emphasizing the fact that analgesia can be obtained with minute doses of cocaine if injected with large quantities of fluid. His method is known as "anæsthesia by infiltration." Later experiments have emphasized the importance of his discovery, although they have disproved some of his minor theories. The analgesia of pure water, for example, is an analgesia of irritation following the hyperæsthesia caused by the water. If successive small amounts of sodium chloride are added to pure water, the irritation caused by the injection of water gradually diminishes. When the solution attains a strength of 0.55 per cent., the irritation ceases and the analgesic effect also disappears. The irritation and analgesia remain absent until the strength of the solution reaches 2.5 per cent. and then they both reappear. Taking 0.9 per cent. as a mean between these two figures one has a salt solution which is least irritating to the tissues. The freezing point of this solution is the freezing point of blood serum. It is therefore osmotically indifferent when injected into the tissues. It has also been proved that the solutions of various other alkalies and salts, made of such strength that their freezing points are the same as that of blood serum, do not irritate when injected into the tissues, and consequently have no analgesic effect.

With regard to morphine, it may be said that a solution of four per cent., which has the same freezing point as blood serum, produces severe burning and hyperæsthesia and afterward analgesia. This solution is, of course, too strong to be used as a local analgesic. As the solution is diluted its local analgesic effect rapidly diminishes, while the local poisonous effect is retained. A solution of 0.1 per cent. has no effect upon the sensitiveness of the skin, but it produces a well-marked wheal, which itches and burns like the bite of an insect. This local poisonous effect of morphine is observed even if the solution employed is as dilute as 1 : 100,000 parts of water, although such a solution contains so little morphine that its presence cannot be proved by any chemical test.

Many other substances have been hailed as substitutes for cocaine, but with one exception they are inferior to it, either on account of the local irritation which they cause, or because they do not produce a satisfactory numbness, or because they are even more poisonous than cocaine. Take, for instance, aneson, a watery solution of acetonchloroform, which has a freezing point of 0.18° C. To bring this to the level of the freezing point of blood serum, 0.35° C., requires an addition to the solution of 0.6 per cent. of salt. Even then the injection of aneson is somewhat painful. It produces analgesia lasting several minutes. If diluted still further, the irritation is less, but the analgesic power rapidly diminishes. For practical use it cannot be diluted with more than three parts of an indifferent medium. Such a solution of aneson is equivalent in analgesic power, therefore, to a cocaine solution of 0.02–0.05 per cent.

Comparing the poisonous effects of the two solutions, cocaine is found to be far less dangerous. Whereas 100 cm. of the solution of aneson will render a rabbit unconscious for twenty-four hours, 100 cm. of a 0.05-per-cent. cocaine solution will have hardly any effect upon the rabbit's general condition. Guaiacol, orthoform, holocaine, and eucaine A all irritate or injure the tissues and fall far below cocaine in analgesic value. Tropacocaine stands nearer to it, though it has a slight local irritating effect. But its poisonous properties are less marked than those of cocaine, and its solutions, besides keeping well, may be boiled without loss of analgesic power. For use it should be dissolved in a 0.6–0.8-per-cent. salt solution, to the amount of 0.1–1.0 per cent. Such a solution will be osmotically indifferent and can be used with satisfaction. The advantages of tropacocaine are, however, overshadowed by those of eucaine B.

The best local analgesic thus far discovered is known as eucaine B. Numerous experiments have shown that this substance is less poisonous than cocaine; that its specific irritation is even less than that of cocaine; that its solutions may be kept for a longer time without change, and may be sterilized by boiling without loss of strength. Most important of all, its analgesic power is

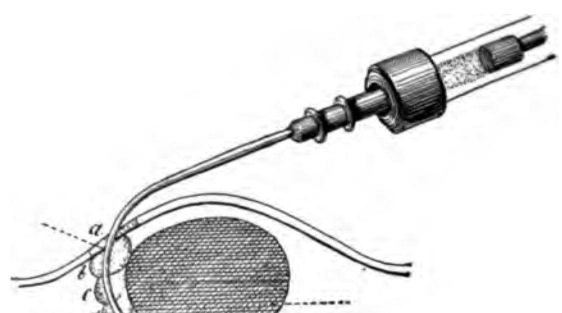

FIG. 197.—Showing Injection Around Tumors with Curved Needle. *G*, Ganglion; *S*, skin; *T*, tendon and sheath; *a*, *b*, *c*, etc., first, second, third, etc., points of injection. (From Schleich.)

equal to that of cocaine, and the analgesia lasts as long. It may indeed be considered the ideal drug of its kind. The solution of eucaine B recommended by Braun—who has done as much as any one to place the subject of local analgesia on a strictly scientific basis—contains 1 part of eucaine B, 8 parts of sodium chloride, and 1,000 parts of water. He has used this mixture in a great number of cases with entire success and with complete absence of toxic symptoms. This solution produces analgesia in a few minutes at any temperature. If, however, the tissue into which it is to be injected is particularly sensitive, for example in the presence of inflammation, tempera-

ture irritation may be avoided by warming a solution to the body temperature before injecting it.

The duration of analgesia increases with an increase in the strength of the solution of cocaine or eucaine employed. Thus the analgesia produced by a 0.02-per-cent. solution of cocaine will last six minutes, that of a 0.1-per-cent. solution, fifteen minutes, that of a 1.0-per-cent. solution, twenty-five minutes, while the analgesia of very strong solutions will last from one-half an hour to an hour. These figures, which are of course approximate and not absolute, are about the same for cocaine and eucaine.

A strong solution of cocaine or eucaine will diffuse itself throughout the neighboring tissue, and in a short time exert an analgesic power beyond the immediate area distended by the injection. If the blood supply of the part is cut off or reduced by a bandage or tourniquet, this diffusion will extend even more widely, since the drug will not so quickly be carried away by the flow of blood. With the diluter solutions diffusion beyond the area distended by the fluid scarcely takes place at all, so that it is necessary to inject the fluid wherever the knife is to follow.

In operations upon a finger or toe the eucaine may be injected circularly around the member; in this manner all of the cutaneous nerves will be benumbed, so that an operation upon the distal portion of the finger will produce no pain. This method of anæsthesia, called regional anæsthesia, was first introduced by Oberst.

The hypodermic needle employed for anæsthesia should be of the finest and sharpest. There is no comparison in the amount of pain caused by pushing a coarse, blunt needle into the tough skin and that produced by a sharp needle of the smallest calibre. If this precaution is observed it will never be necessary to freeze the skin before the puncture is made, for the pain caused by the insertion of such a needle is merely like a pin prick. The first puncture should never be made in an inflamed area if it is possible to avoid it, but in the sound skin close by. The second puncture can be made in the farther edge of the first, and the third in the farther edge of the second, and so on until the inflamed area has been anæsthetized, absolutely without pain (Fig. 195).

What operations are suitable for local anæsthesia must be determined by the individual surgeon. Laparotomies can be performed under local analgesia, or a thigh may be amputated absolutely without pain by this means. Such operations have sometimes been performed with the use of cocaine, but it does not follow that because they are possible they ought, therefore, to be advised. Other considerations must come in, and the necessity for haste, the advantages or disadvantages of allowing the patient to retain consciousness, the necessity for manipulation of the surrounding organs, the importance of muscular relaxation, and other points will have immediate bearing upon the choice of an anæsthetic. There are doubtless instances in which the general condition of the patient will incline the surgeon to the performance of major operations with the help of a local anæsthetic, which under other circumstances he would always perform with a general anæsthetic. It was at one time supposed that broncho-pneumonia, which sometimes kills a patient upon whom a severe operation has been performed while under the influence of ether or chloroform, might be avoided by the use of cocaine. Unfortunately, this has not proved to be the case, as broncho-pneumonia may also follow a severe operation upon an enfeebled patient, even though no general anæsthetic is given.

Decision will rest no less upon the character of the patient to be operated upon, than upon the character of the operation to be performed. Very young children, and nervous persons to whom the thought of the knife is fully as distressing as the pain of its cutting, will be saved a great deal of shock if given a general anæsthetic; while the surgeon under such circumstances will be able to give his undivided attention to the work in hand, which will not be the case if pain is dulled by eucaine or cocaine. Many persons, on the other hand, have a dread of suspended consciousness, which will lead them to suffer a considerable amount of pain rather than to submit to etherization. The practical plan, in all doubtful cases, is to prepare the patient for a general anæsthetic, and to have it ready. Then the patient will receive the local injections in the comforting confidence that if they fail to relieve him of pain, he can drown his woes in the ether cone. It has been the experience of the writer and others, that under these circumstances the general anæsthetic is rarely asked for.

There are some lesser operations, however, which ought never to be performed with the help of a local anæsthetic—such operations as the dissection of an axilla whose glands are the seat of cancerous deposits, and in general any operation the success of which depends upon the recognition of the line between diseased and healthy tissue. The local anæsthetic, even though it be an osmotically perfect solution, causes an œdema which makes it more difficult for the surgeon to tell how far the disease extends. Under these circumstances a general anæsthetic should always be given.

The only method of producing local analgesia by drugs thus far spoken of is the method by injection. The application of cocaine to the skin will not produce analgesia, unless the drug is driven into it by means of a strong galvanic current—the method of cataphoresis, as it is called. But mucous membranes are capable of absorbing a sufficient amount of cocaine to render them insensitive. For this purpose the solution employed must be far stronger than that employed in the infiltration method, though there is no doubt that unnecessarily strong solutions have been used upon the mucous membranes. Several fatal cases have been reported from the injudicious use of cocaine upon mucous membranes. One drachm of a four-per-cent. solution, injected into the urethra, has caused the death of an adult inside of four minutes, while half of that amount has killed a child within three days from the time of injection. Smaller quantities have caused alarming though not fatal symptoms. In every case in which cocaine or any other drug is injected the surgeon ought to know exactly how much he is administering. The minimum fatal dose of cocaine for an adult is certainly not more than one-third of a grain. This amount is contained in seventeen minims of a two-per-cent. solution, or in eight minims of a four-per-cent. solution. The injection into the urethra of a twenty-per-cent. solution is absolutely unwarrantable, while the practice of anæsthetizing the nasal cavities by means of a spray is also to be condemned. Instead, the drug should be applied on a swab, and then the operator will know how much of the drug he is applying.

The sensibility of a considerable portion of the body can be reduced or even entirely suspended by the injection of a small amount of cocaine by a lumbar puncture into the spinal canal. Fifteen minims of a one-per-cent solution injected in this manner have sufficed to render insensitive to pain, for a half-hour or more, the whole lower half of the body of an adult. Rather extensive operations have been performed in this manner, but they might have been done equally well, apparently, by means of injections made locally, while the lumbar punctures were followed in almost every instance by headaches and pain in the back and legs for a day or longer, and in some instances by attacks of vomiting for several hours. These unpleasant symptoms were equally marked in the one instance in which tropacocaine was employed instead of cocaine, so that analgesia by lumbar injections has not yet passed beyond the stage of scientific experimentation, and it is doubtful if it will do so.

In spite of all that has been written in favor of the use of dilute solutions of cocaine, or, better still, the substitution of eucaine B for cocaine, many dangerously strong solutions of cocaine will still be employed. It is not, therefore, out of place to mention the toxic symptoms of the drug, and the appropriate treatment for them. The various symptoms mentioned are pallor, profuse perspiration, frequent, feeble, irregular, or intermittent pulse, unconsciousness, dizziness, nausea, blindness, deafness,

muscular rigidity, lividity, convulsive or suspended respiration, and paralysis. In the slighter cases of poisoning, the symptoms are over in a few hours. Among the antidotes recommended are amyl nitrite, nitroglycerin, ammonia, digitalis, whiskey, atropine, and morphine, but above all it is important to place the patient in a horizontal position, to loosen his clothing, and to perform artificial respiration if necessary. Even though attempts at resuscitation are successful, it is not safe to leave a patient for some time afterward, as a second or third collapse may occur.

Another disadvantage which is connected with the use of cocaine is the habit which has often been formed in this manner. This danger is most likely to follow the use of cocaine in the nose. On account of its contractile power, the relief which it affords in inflammatory conditions, such as acute coryza or hay fever, is so prompt and delightful that the desire to repeat the application soon becomes very strong. Even more than morphine the drug soon has a terrible grasp upon the unfortunate sufferer, which few men have ever been able to shake off. Many physicians have fallen a prey to cocaine. Under such circumstances a strong word against its careless use is not out of place here, although the habit has not usually followed its administration for local analgesia.

Edward Milton Foote.

ANÆSTHETICS.—Agents capable of producing privation of sensation, or anæsthesia (from *α*, privative, and *αἰσθάνομαι*, I feel), when inhaled or applied locally, have been termed anæsthetics. While the word "anæsthesia" more properly indicates the *condition* of want of sensibility or feeling, it has also been applied and is commonly used to denote the *state* produced by the administration of the general anæsthetics, of which want of feeling is but one of many factors. The word "narcosis" (from *νάρκωσις* or *νάρκη*, numbness or paralysis) is also much employed to signify the *state* of the anæsthetized individual, and will be so used in this article. Agents which act upon the whole organism by their absorption into the blood are called *general* anæsthetics. Those which act only upon the part to which they are applied are called *local* anæsthetics.

ANCIENT HISTORY.—To seek relief from pain is instinctive and the practice of measures for this purpose is undoubtedly of as great antiquity as man's existence. Efforts to obtain freedom from suffering during surgical and other painful procedures are recorded throughout ancient history, and the works of the earliest medical writers contain numerous references to methods in vogue in their times for the mitigation or prevention of pain, through the exhibition of drugs by internal administration, by inhalation, and by local application.

Mandragora, cannabis indica, and opium are the agents that were most commonly used for this purpose, although belladonna, hyoscyamus, hemlock, and others are frequently mentioned in this connection. Mandragora (atropa mandragora) seems to have been the earliest and most favored narcotizing agent of the ancients, and must have been in general use in the times of Dioscorides, Pliny, and Apuleius, for in their writings its action and uses are freely discussed.

Dioscorides mentions three different preparations of mandragora in these terms: 1. "Some persons boil the root in wine down to a third part and preserve the decoction, of which they administer a cyathus [℥ iss.+] in want of sleep and severe pains of any part, and also before operations with the knife or the actual cautery, that they may not be felt." 2. "A wine is prepared from the bark of the root without boiling, and three pounds of it are put into a cadus [about eighteen gallons] of sweet wine, and three cyathi of this are given to those who require to be cut or cauterized, when, being thrown into a deep sleep, they do not feel any pain." 3. Of another kind of mandragora called "marion" he states: "They relate that a drachm of it being taken as a draught, or eaten in a cake or other food, causes infatuations, and takes away the use of the reason. The person sleeps without sense, in the attitude in which he ate it, for three or four hours afterward. Medical men also use it when they have to resort to cutting or burning."

Pliny, writing of the juice of the leaves of mandragora, states that "it has a soporific power on the faculties of those who drink it; . . . the dose is half a cyathus; . . . some persons even die from a considerable draught; . . . it is taken against serpents, and before cuttings and puncturings, lest they be felt."

Apuleius has written of mandragora: "If any one eat it he will immediately die, unless he be treated with butter and honey and vomit quickly. Further, if any one is to have a limb mutilated, burnt, or sawn, he may drink half an ounce with wine, and whilst he sleeps the member may be cut off without any pain or sense."

Cannabis indica, which is probably the "hasheesh" or "bhang" of the East, the Ma yo of the Chinese, and the "nepenthe" of Homer, was employed by the Scythians, as related by Herodotus, for the production of intoxication. In the East it has long been used for this purpose and for the relief of pain, particularly in the case of criminals about to undergo torture. An example of the use of cannabis indica to prevent the pain of surgery occurs in a biographical sketch of Hoa tho, a Chinese practitioner, of whom it is stated that "if the malady was situated in parts on which the needle, the moxa, or liquid medicines could not act, for example in the bones, in the medulla of the bones, in the stomach, or the intestines, he gave the patient a preparation of hemp, and, at the end of some instants, he became as insensible as if he had been drunk or deprived of life. Then, according to the case, he made openings and incisions, performed amputations, and removed the cause of the malady; he then brought together the tissues with points of suture and applied liniments. After a certain number of days the patient found himself re-established without having experienced the slightest pain during the operation."

Cannabis indica was almost invariably administered by the inhalation of its fumes when burnt, and Pliny, in recording the properties of the juice of mandragora leaves, states: "For these purposes [against serpents and before cuttings and puncturings, lest they be felt] it is sufficient for some persons to have sound sleep from the smell [of the medicine]."

In the thirteenth century Theodoric produced insensibility to the pain of operations by means of narcotic inhalations from a "sleeping ball" or "spongia somnifera," used and described by his teacher, Dominus Hugo of Lucca, and thus made: "Take of opium and the juice of unripe mulberry, of hyoscyamus, of the juice of the hemlock, of the juice of the leaves of the mandragora, of the juice of the woody ivy, of the juice of the forest mulberry, of the seeds of lettuce, of the seed of the burdock which has large round apples, and of the water hemlock, each one ounce; mix the whole of them together in a brazen vessel, and then in it place a new sponge, and let the whole boil as long as the sun lasts on the dog-days until the sponge consumes it all and it is boiled away in it (the sponge). As oft as there shall be need of it, place this sponge in hot water for an hour and let it be applied to the nostrils of him who is to be operated on till he has fallen asleep: and so let the surgery be performed. This being finished, in order to awaken him, apply another sponge, dipped in vinegar, frequently to the nose, or let the juice of the roots of fenugreek be squirted into his nostrils. Presently he awakens."

Although the efficiency of this plan has been doubted, it is recorded that in 1832 M. Dauriol in France, following these directions, operated painlessly in five cases, which he reported. Greek and Roman authors have described the effects of mandrake in preventing the pain of operations, but it seems to have been little used by them on account of its fatal effects; in fact, it is probable that all of the foregoing means of rendering surgery painless were dangerous.

Pliny and Dioscorides describe the local benumbing

effects produced by the application of pulverized marble (memphitis) with vinegar, stating that it will "stupefy parts to be cut or cauterized, for it so paralyzes the part that it feels no pain." Numerous other methods of producing insensibility to the pain of surgical operations are recorded, notably compression of the vessels of the neck as practised by the ancient Assyrians during circumcision, which probably acted by producing the unconsciousness of cerebral anæmia (as also brought about by excessive and rapid venesection for similar purposes); compression of the nerves supplying the part operated upon, as carried out with some success in 1784 by James Moore, an English surgeon. Hypnotism, which "was known to the Indians, Egyptians, and Persians at a very remote period," has been extensively tried as a means of rendering patients insensible to the pain of operations. Cloquet removed a breast painlessly from a hypnotized patient in 1829, and at a later period Esdaile in India performed several hundred operations upon patients, chiefly Hindoos, in the hypnotic state. Elliotson and Braid advocated the method in England, and Liston employed it with some success. Simpson investigated the subject thoroughly and made many very successful experiments with it, but abandoned it as impracticable. The practice of hypnotism for the production of anæsthesia has never come into general use and probably never will, from the fact that only a very small percentage of persons can be satisfactorily put into this state, and in these, repeated attempts are often necessary before a sufficiently deep sleep can be induced so that the subject will be insensible to pain. Furthermore, the condition of the patient during the operation is often far from satisfactory on account of "convulsive movements of the limbs, corrugation of the brows, and even loud cries and sobs," which occur in many cases.

For a long period before the introduction of the anæsthetics of to-day, opium and alcohol were the chief agents employed to lessen operative pain; but the results were far from satisfactory, and M. Velpeau in 1839 wrote: "To escape pain in surgical operations is a chimera which we are not permitted to look for in our day. A cutting instrument and pain, in operative medicine, are two words which never present themselves the one without the other, in the mind of patients, and it is necessary for us as surgeons to admit their association."

Modern History.—The incidents leading up to the discovery of the anæsthetic properties of nitrous oxide, ether, and chloroform, and the introduction of these agents into surgical practice, form one of the most interesting chapters in medical history. In 1799 Humphrey Davy published on account of his extensive researches concerning nitrous oxide, and stated that "as nitrous oxide, in its extensive operation, appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place." Even before this time ether was used by inhalation for the relief of affections of the chest and was known to relieve pain and promote sleep. In 1818 Faraday is said to have pointed out that the inhalation of ether vapor produced effects similar to those of nitrous oxide. The intoxication resulting from the breathing of diluted vapors of these agents became very well known, and was commonly practised as a means of pleasure and amusement. During an exhibition of this kind in Hartford, Conn., on December 10, 1844, Horace Wells, a dentist of that place, took note of the fact that while under the influence of "laughing gas" a Mr. Cooley sustained an injury of the leg without the least evidence of pain. The following day Wells inhaled the gas and had a large molar tooth extracted. As he recovered consciousness he stated that it had not hurt him "more than the prick of a pin," and that it would create "a new era in tooth-pulling," a prediction that has been fully realized, although Wells did not live to see it. After his own experience he immediately tried the gas in his practice with great, though not invariable, success. In a public demonstration of its action at the Harvard Medical School a short time later, the patient—owing no doubt to the imperfect method of administration employed—gave unmistakable signs of pain upon the extraction of a tooth. Wells was hissed and ridiculed by the students present; and although discouraged and believing the gas to be uncertain in its action, he continued to use it in his practice for a number of years.

Wells died in 1848, and nitrous oxide was generally discredited till 1867, when Colton reported twenty thousand successful administrations. After this it rapidly assumed its present status as an anæsthetic. This demonstration of the action of nitrous oxide is not generally looked upon as the discovery of anæsthesia, though in Hartford a monument erected to Wells is thus inscribed:

Horace Wells, who discovered Anæsthesia,
December 10, 1844.

William T. G. Morton, a dentist of Boston and a partner of Wells in 1842–43, devised an improvement in making artificial teeth which necessitated the extraction of all old roots, over which the plates were made and worn at that time. Great difficulty was experienced in inducing patients to submit to this operation on account of the pain, and Morton sought diligently for better methods of preventing it than by the administration of enormous doses of alcohol or opium, commonly used at this time for such purposes. Familiar with the action of nitrous oxide, and knowing the similar effects of ether, he was led to experiment with the latter upon himself and on animals. After succeeding in completely etherizing a dog, he rendered himself unconscious for over seven minutes by inhaling ether from a handkerchief. This occurred on September 30, 1846, and the same evening he administered it to a patient for tooth extraction with perfect success. Within a week he requested Dr. John Collins Warren, a prominent surgeon of Boston, to permit him to administer the agent for him in a surgical operation, and this was done at the Massachusetts General Hospital on October 16, 1846, with such success that Dr. Warren, a very conservative man, exclaimed to the large audience of medical men and students present: "Gentlemen, this is no humbug!"

This was the first public demonstration of the action of ether as an anæsthetic, and although numerous claims of priority have been made, Morton is generally credited with giving the inestimable gift of anæsthesia to the world. The knowledge of this discovery and its use in dentistry and surgery spread with great rapidity. Ether was first administered in England on December 19, 1846; a few days later it was employed in France, and in a remarkably short time its use became almost universal. On January 19, 1847, Simpson first employed ether during labor for forceps delivery, and a few days later to relieve the pain of ordinary labor. He immediately called the attention of the profession to the subject, and notwithstanding widespread and outspoken objections to anæsthetics in these cases, and even in surgery, upon the religious opinion that pain under these circumstances was the will of God and should therefore be borne, their use has become almost a routine practice the world over.

The success of ether as an anæsthetic incited a large amount of experimentation with almost every substance, in the hope of discovering a better agent for this purpose, and on November 4, 1847, the anæsthetic property of chloroform was discovered by Dr. James Y. Simpson, who, with his assistants Dr. George Keith and Dr. Matthews Duncan, inhaled it from tumblers and were all rendered unconscious thereby. On the 10th of the same month Simpson read a paper on chloroform before the Medico-Chirurgical Society of Edinburgh, and on the 15th published a pamphlet on the subject, reporting about fifty successful administrations. The apparent advantages of chloroform over ether caused it largely to replace the latter throughout the world, with the notable exception of the northeastern part of the United States, where faith in ether has never been shaken and chloro-

form, though tried at the time of its discovery as an anæsthetic, was quickly dropped on account of its dangerous action.

On January 28, 1848, less than three months after the introduction of chloroform, a death during its administration occurred, and this was soon followed by reports of others from every quarter of the globe.

From that time to the present, chloroform fatalities have been recorded with great and apparently increasing frequency, while deaths from ether have been comparatively rare. To these facts may be attributed in great part the steady gain of ether throughout the world.

Since the introduction of nitrous oxide, ether, and chloroform as anæsthetics, a large number of similar substances have been found to possess this property, and several of these have been used to some extent. None, however, has stood the test of time as have the three above mentioned, which to-day constitute practically the only agents in general use.

Methylene bichloride, discovered by Regnault in 1840, recommended as an anæsthetic by Sir B. W. Richardson in 1867, and warmly advocated by Sir Spencer Wells, was used very considerably in Europe for a number of years. Its favorable features were, agreeable odor, rapid action, prompt recovery, and freedom from after-effects; but it proved to be unsafe and fell into disuse. It was furthermore found that the substance commonly used as bichloride of methylene was really chloroform diluted with one-fifth of methylic alcohol, and that genuine "methylene" acted as a convulsive poison in the lower animals.

Ethidene dichloride, discovered by Regnault and used to the extent of one thousand eight hundred and seventy-seven administrations by Clover, enjoyed some popularity for a time, but its use never became general. Its action was evidently between that of chloroform and that of ether. Several deaths and accidents are recorded from its use.

Ethyl bromide, discovered by Serullas in 1827, was first used as an anæsthetic by Nunnely in 1849 and was employed to some extent by Turnbull, Chisholm, J. Marion Sims, R. J. Levis, Sir B. W. Richardson, Mr. Clover, J. F. Silk, and others. It was studied experimentally by Rabuteau, Berger, Wood, Wolff, Lee, Ott, Lyman, and others, and was found, if given freely, to be a powerful circulatory and respiratory depressant. It was very apt to contain bromic impurities and was easily decomposed. Clinically it was found to be an exceedingly rapid anæsthetic, about one minute being sufficient for the production of deep anæsthesia, and, if at once discontinued, Silk demonstrated that an average anæsthesia of 46.2 seconds resulted. Recovery was prompt and very free from after-effects in the short administrations, though headache, faintness, and vomiting often followed its prolonged use. Muscular rigidity was often encountered during its inhalation. It caused "great congestion of the face, neck, and upper part of the chest." The pulse and respiration were usually accelerated. Lachrymation and salivation were often very great; the pupils were usually dilated. Several fatalities resulted from its administration, and although it was used by many with great satisfaction, particularly in momentary or short operations, its present use is not extensive, and it is not generally recommended as an anæsthetic. Fowler has recently commended its use in one or two drachm doses, preliminary to ether.

Ethyl chloride, discovered by Ravelle and studied by Basse, has been successfully employed as an anæsthetic by Heyfelder, Lotheisen, Hacker, Rodier, Weissner, and others. Anæsthesia is induced very rapidly, from half a minute to two minutes being required, according to the individual. If immediately discontinued, anæsthesia lasting from half a minute to three minutes has been obtained, the length of the anæsthesia corresponding to the length of the administration. Recovery has been very free from the usual disturbances. Muscular relaxation is not obtained from this anæsthetic and the patient is apt to regain consciousness during the operation. The administration of ethyl chloride as a general anæsthetic has not been extensive up to the present time, and further researches will be necessary before its true value is determined. As a local anæsthetic its properties are well known. Tuttle has recently recommended its administration preliminary to ether.

Amylene, discovered by Balard in 1844, was carefully studied by Snow in 1856–57. Two deaths occurred under its influence out of the two hundred and thirty-eight cases in which he used it, and it was discarded, although it had been given rather extensively for a while. As an anæsthetic it was not very satisfactory. It did not produce muscular relaxation, but with very light narcosis complete analgesia seemed to be present, and most of Snow's cases were operated upon in this state. The vapor of amylene is not pungent, but has an "offensive, cabbage-like odor." It is no longer used.

Pental is said to be "a pure form of amylene introduced into commerce by Mering." It has been used to a limited extent, particularly for short operations. Its action is similar to that of amylene, though quicker and more constant. Dangerous symptoms and deaths have occurred under it, however, and it is little used at present.

Nitrogen, pure or in combination with small percentages of oxygen, produces unconsciousness which closely resembles the anæsthesia of nitrous oxide. It is not a true anæsthetic, however, its action depending solely upon deprivation of oxygen and consequent asphyxia. Hewitt has employed it in twenty-three cases of tooth extraction, practically pure nitrogen being used in some and in others nitrogen plus oxygen in the proportions of 3, 5, 6.6, 7, and 7.5 per cent. Although anæsthesia was produced in all of the cases, it was not as satisfactory as that of nitrous oxide. The time of administration varied from fifty to ninety-five seconds, according to the amount of oxygen present. The resulting anæsthesia was somewhat shorter than that of nitrous oxide and the after-effects were greater.

A large number of substances similar to those already mentioned have been found to possess anæsthetic properties, but owing to disadvantages, dangers, and the knowledge of better agents, they are not used.

In the hope of favorably modifying the action of the more commonly employed anæsthetics, ether and chloroform, various mixtures of these agents with each other and with other substances have been proposed. The A.C.E. mixture, probably the best known of these, consists of alcohol 1 part, chloroform 2 parts, and ether 3 parts by volume. Martindale states that almost uniform volatilization of this mixture results if the specific gravity of the alcohol is 0.795, the chloroform 1.497, and the ether 0.720. This mixture, originally advocated by Harley, was strongly recommended by the anæsthetic committee of the Royal Medico-Chirurgical Society of London, its action being found by them to be about half way between that of chloroform and ether. This committee also recommended a mixture of chloroform 1 part, ether 2 parts, and another of chloroform 1 part, ether 4 parts, but gave preference to the first or A.C.E. mixture on account of its "uniform blending" and "probably the more equable escape of the constituents in vapor."

Other well-known mixtures are: The Vienna mixture—chloroform 1 part, ether 3 parts; Billroth's mixture—chloroform 3 parts, alcohol 1 part, ether 1 part; Linhart's mixture—chloroform 4 parts, alcohol 1 part; Sansom's mixture—chloroform and alcohol equal parts.

In 1895, Schleich, of Berlin, advanced the theory that an anæsthetic mixture the boiling point of which closely approximated the temperature of the body, would possess great safety and cause the minimum of after-disturbance by reason of the definite and suitable relations thus established between absorption, elimination, and the amount of the agent retained in the circulation. He suggested three different mixtures, as follows:

	No. 1.—Boils 38° C. (100.4° F.). For light narcosis.	No. 2.—Boils 40° C. (104° F.). For medium narcosis.	No. 3.—Boils 42° C. (107.6° F.). For deep narcosis.
Chloroform	45 volumes.	45 volumes.	30 volumes.
Sulphuric ether.....	180 "	150 "	80 "
Petroleum ether....	15 "	15 "	15 "

The petroleum ether used should boil at from 60° to 65° C.

These mixtures enjoyed a brief popularity, and were earnestly recommended in the United States by Maduro, Meyer, and others. Many advantages were at first claimed for this form of anæsthesia—*i.e.*, safety, marked freedom from excitement, cyanosis, flow of mucus, bronchitis, pneumonia, vomiting. Very rapid recovery and slight effects upon the heart, lungs, or kidneys were observed. Clinical evidence, however, soon disproved these claims, and cases of deep cyanosis, alarming states of the respiration and circulation, nearly fatal accidents, excessive vomiting, broncho-pneumonia, albuminuria, etc., occurred with such frequency that a number of those who had at first advocated the method with enthusiasm later published their reversed conclusions.

In 1898 Dr. Willy Meyer brought forward a new mixture "on the basis of the Schleich principle," as follows:

Ethyl chloride	....	17 volumes.
"M. S."	Ether, 56.75 volumes; Chloroform, 43.25 "	83 "

The mixture of ether and chloroform designated "M. S." is said to be a true molecular solution containing no free ether or chloroform. The boiling point of the total mixture is 40° C. (104° F.). Dr. Meyer considers this single mixture a great improvement on those of Schleich, and in its use he has observed little general disturbance, no struggling, infrequent vomiting, rapid recovery, and no disturbance of the lungs or kidneys.

Many are opposed to the use of anæsthetic mixtures on the ground that their action is indefinite and that, owing to the marked difference in the rate of evaporation of their respective ingredients, the first effect is chiefly due to the more volatile agent, the later effect to the less volatile.

These, and many other theoretical objections to the use of anæsthetic mixtures, are not borne out by practical experience, and they are extensively used and have been given a definite place by most writers on anæsthesia.

Minor and others have demonstrated that the boiling point of a given anæsthetic mixture is not constant on its evaporation. It is probable that the action of such a mixture is that of its most powerful ingredient modified by dilution and by the effect of the other ingredients.

Tyrrell has advocated the administration of mixtures of the *vapors* of ether and chloroform in proportions to suit the effect desired, and has devised an apparatus for this purpose consisting of two Junker bottles, a single bellows, and a mechanism for regulating the proportions of the vapors.

The administration of anæsthetics in succession to one another forms a distinct method of practice, and the plan is attended with numerous advantages. "Gas and ether," which consists in the administration of nitrous oxide before ether, is perhaps the best example of this, and its advantages are as follows: the induction of unconsciousness is almost ideal, being accomplished in from ten to twenty seconds with practically no discomfort, such as attends the breathing of agents which have a strong and more or less pungent odor; complete ether narcosis may be obtained in from two to four minutes from the beginning of the gas, with entire absence of a stage of excitement. Chloroform before ether is frequently resorted to in order that the patient may have the comfort of the more agreeable and less pungent odor of the former and to avoid the mental effect often produced upon the patient by the more formidable-looking apparatus used for the administration of the latter. In this plan it should not be forgotten that a large percentage of the deaths from chloroform have occurred during the early part of its administration.

Chloroform mixtures before ether are less dangerous and nearly as pleasant. Ethyl bromide and ethyl chloride before ether produce unconsciousness nearly as quickly as gas, but are less pleasant to inhale. The succession of gas, ether, and chloroform is suitable for those cases in which the latter agent is indicated and in which it is desirable to avoid the conditions present during the stage of excitement. The condition of the respiration and circulation under nitrous oxide renders the succession of gas and chloroform a dangerous procedure, and it should not be undertaken.

A change from one anæsthetic to another is often advantageous during an administration. Thus the sedative and depressing effects of chloroform are counteracted by the previous or subsequent administration of ether; and the irritation or excessive stimulation of ether is overcome by changing to chloroform.

A distinct method, often referred to as "mixed anæsthesia," consists in the administration of morphine, alone or with atropine, in conjunction with ether or chloroform. The plan is the outcome, in great part, of the experience of Nussbaum, Bernard, Guyon, Labbe, Kappeler, Julliard, Dartre, and others. The advantages claimed for this method are, that the narcosis is strikingly quiet and smooth, free from excitement, struggling, salivation, and the usual after-effects, and that narcosis is established and maintained by a very small amount of the anæsthetic.

These advantages are undoubtedly pronounced, and the method is employed by many with great satisfaction. Morphine given subcutaneously an hour or two before the operation, so that the full effect is well established by that time, usually renders the patient calm, sleepy, and in an admirable frame of mind for taking the anæsthetic.

Unfortunately, the plan presents certain disadvantages. The action of morphine is greatly intensified in the presence of ether or chloroform, and its excessive action is not infrequently undesirable or dangerous. Alarming respiratory depression and prolonged deep stupor have followed its use, as observed by Dartre, Demarquay, Regnier, Lucas, Hewitt, and others. Regnier and Lucas have witnessed a number of deaths which they attribute to this method, and others have abandoned it on account of these disadvantages. The action of the anæsthetic is also increased in the presence of morphine and an overdose is more easily administered. Regnier asserts that morphine lessens the elimination of chloroform and thus favors its dangerous accumulation in the system. In view of these facts, it is the writer's opinion that this modification of anæsthesia is not suitable as a routine practice, although in selected cases it may often be of great value. Clinical experience has demonstrated that the method is contraindicated in weak subjects, in those presenting respiratory insufficiency, and particularly if dyspnœa from any cause is present; in patients presenting any degree of stupor; in operations likely to be attended by excessive hemorrhage, and in patients who are very susceptible to the action of morphine.

Its application would seem to be particularly advantageous in highly excitable, vigorous, and neurotic individuals, in alcoholics, and in those in whom it would be especially desirable to administer the least possible amount of the anæsthetic, on account of acute or advanced cardiac, pulmonary, or renal disease. It has been recommended for operations about the mouth on account of the slow recovery permitting the removal of the inhaler for prolonged periods. It must be remembered, however, that morphine allays the reflex excitability of the air passages, and that danger of the entrance and toleration of products of the operation or other foreign matter in the lungs is thereby increased. Morphine in doses ranging from gr. $\frac{1}{6}$ to gr. $\frac{1}{4}$, alone, or combined with from gr. $\frac{1}{150}$ to gr. $\frac{1}{100}$ of atropine, are those usually recommended for this purpose. It is obvious that the dose should be chosen to meet the conditions

presented by each case and the effect desired, rather than that a stated amount should be administered in the usual dogmatic way. In view of the augmented action of morphine in the presence of ether or chloroform, satisfactory effects are usually produced by the exhibition of much smaller doses than those commonly employed, and it will be found that from gr. $\frac{1}{16}$ to gr. $\frac{1}{8}$ is usually sufficient. Chloral has also been used before anæsthesia on the same principle as that governing the use of morphine, but the results have not been favorable; danger of collapse being rather increased in the case of chloroform and the after-effects being exaggerated in the case of ether. Other hypnotics have been tried in this way with some success, but the results have not been pronounced enough to lead to their general adoption.

The administration of oxygen during anæsthesia has received much attention, especially its use in conjunction with nitrous oxide, the administration of which in a pure state is complicated by asphyxia resulting from deprivation of oxygen. The investigations of Bert, Hellischer, Hewitt, and others have demonstrated that this asphyxia may be eliminated by combining oxygen with nitrous oxide, without interfering with the production of narcosis. In 1878 Bert produced perfect and long-continued anæsthesia in dogs with a mixture of about eighty three per cent. nitrous oxide and seventeen per cent. oxygen administered under an atmospheric pressure increased by one fifth. The year following, the method was successfully employed in human subjects and attracted much attention. Bert later succeeded in narcotizing animals with gas and oxygen at the normal atmospheric pressure. Hillischer made use of the combination with great success in over fifteen thousand dental cases. Hewitt has made a particular study of this subject, and has demonstrated that although no definite mixture of these gases will produce anæsthesia without asphyxia in all cases, one containing ten or twelve and one half per cent. of oxygen proved quite satisfactory in average cases. The best results, however, were obtained by using a regulating apparatus by means of which the gases could be administered in proportions to suit the case in hand and the conditions as they arose during the narcosis. Oxygen has been recommended in conjunction with ether and chloroform by numerous observers (Neudorfer, Foy, Kreutzmann, Northrop, Cole, Buxton, and others), and while it is probable that oxygen is not an antidote to these agents and will not prevent their fatal effects when administered in an overdose, there is no doubt that its use will obviate the asphyxia which frequently complicates their administration, thereby removing an unpleasant and occasionally dangerous element of the narcosis.

Experience has demonstrated that chloroform and ether may be administered in such a manner that the patient does not suffer from lack of oxygen, and it is therefore evident that the routine use of this agent during anæsthesia is uncalled for. Buxton calls attention to a possible danger in its use as follows: "The supply of oxygen keeps the patient of a cherry-red color, and chloroform is pumped on until the respirations stop through poisoning of the medulla. No peripheral duskiness or gradual failure of respiration appears, as the tissues remain red until circulation and respiration cease." It has been suggested that a small proportion of amyl nitrite added to chloroform might offset the dangerous effects of the latter, and this combination has been highly spoken of by Sanford, Balliet, Sir B. W. Richardson, and others. The anæsthesia is said to be characterized by greater circulatory stimulation than when chloroform is used alone. Sanford employed a mixture of two drachms of amyl nitrite to a pound of chloroform, Balliet a mixture containing sixteen drops to the ounce.

In view of the physiological action of amyl nitrite, it would seem that while its use in this way with chloroform might be very satisfactory for brief administrations, the powerful primary stimulation of the former counteracting the not infrequent primary depression of the latter, its prolonged use would be hazardous on account of its later paralyzing action on the vessel walls and its depressing effect upon the heart.

Physiological Action.—Before taking up the action of anæsthetics in the production of narcosis, it may be of interest and significance to consider other instances of their power. The luminous oxidation of phosphorus in air is suspended in an atmosphere slightly impregnated with chloroform or ether, and in like manner the flame of a candle may be extinguished by the addition of chloroform vapor to the surrounding air. In the presence of anæsthetic substances fermentation does not occur, certain chemical reactions are prevented, movement of the leaves and respiration in plants are arrested, and the germination of seeds and the hatching of eggs are checked. These effects are transient if the exposure has not been too long continued or the strength of the vapor too great. In the latter event the life of organic matter of any kind may be destroyed.

The effect of anæsthetics upon isolated tissues of the animal economy demonstrates that they have the power of arresting the functional activity of all its parts. The nature of this action is not clearly understood, but it apparently consists in paralysis or immobilization of the ultimate cellular elements. Claude Bernard demonstrated that the posterior extremities of the frog can be completely paralyzed by their immersion in a weak chloroform solution, and that if means are employed to exclude these parts from the general circulation the anterior portions of the body remain unaffected. Experiments by Simpson, Nunnely, and others on earthworms, leeches, centipedes, rabbits, and other animals prove that entire members or segments of their bodies may be completely anæsthetized apart from the remainder. Gaskell and Shore produced fatal cessation of respiration by the application of a small amount of chloroform to the fourth ventricle. Waller's experiments relative to the action of anæsthetics on nerves are of great interest. Isolated nerves were exposed, in a moist chamber, to intermittent electrical excitation the responses being recorded by the galvanometer. Under normal conditions the nerves responded with remarkable regularity and endurance, but when exposed to anæsthetic vapors of various strengths the responses to excitation failed more or less completely. The nerves were now said to be "anæsthetized or temporarily immobilized." After brief exposure to air their electromobility was restored, unless the strength of the vapor had been too great, in which event there was no recovery, the nerve being "permanently immobilized or killed."

Coats has demonstrated that "the heart of the frog is very sensitive to chloroform vapor. When the heart is exposed, under a bell jar, to air charged with chloroform, the heart became rapidly weaker, till it ceased beating; to recover when the chloroform atmosphere was removed. In this respect chloroform contrasted with ether."

The inhalation of anæsthetic vapors brings them in intimate contact with the blood through the enormous surface of the pulmonary air cells. Here they are absorbed by the liquor sanguinis and by the blood corpuscles, and are carried to every part of the body, affecting each in proportion to its susceptibility or to its special affinity for these substances. While it is thus evident that all of the tissues must be influenced to some extent, the phenomena of anæsthesia, as induced by inhalation, are due almost entirely to the action of the narcotic upon the nervous system, which exhibits striking susceptibility to the action of all of this class of drugs. This susceptibility is no doubt to be explained by the selective action of anæsthetics upon the tissues of the nervous system according to the principle of a chemical affinity between certain drugs and certain organs, as pointed out by Ehrlich and confirmed in the present instance by the observations of Lallemand, Perrin, and Duroy, that the brain and spinal cord of persons killed by chloroform contain a larger proportion of it than other tissues.

In the production of narcosis it is evident from the

progressive manner in which the signs appear, that the different parts of the nervous system possess different degrees of resistance to this influence, and according to the observations of Flourens, Snow, and others they are overcome in the following order: 1. The cerebrum. 2. The cerebellum. 3. The sensory centres of the cord. 4. The motor centres of the cord. 5. The medulla. According to Anstie, certain signs point to an early involvement of the sympathetic nervous system.

While the ultimate effect of anæsthetics upon the nervous system is to paralyze its various parts, it is a conspicuous clinical fact that this is usually preceded by some degree of excitement and functional perversion. This is due to the fact that all anæsthetics act as stimulants in less than narcotic doses; and since it is necessary, in view of safety, that certain of these, as chloroform and ether, should be administered gradually in a diluted form, a period of excitation and partial narcotism is frequently observed. With nitrous oxide—which is administered pure and the action of which is rapid—such a period is exceedingly rare, and when it occurs, is usually due to the admission of a considerable percentage of air with the gas.

The period of complete narcosis as required for surgical purposes is characterized, so far as the nervous system is concerned, by loss of consciousness and by paralysis of the centres governing sensation and motion, while those which control circulation and respiration are but slightly affected. Mere loss of consciousness is a prominent factor in ordinary surgical anæsthesia, and many operations may be satisfactorily performed with only enough of the anæsthetic to produce this condition, which is one of the earliest manifestations of their action. Painless operations during the unconsciousness of "primary anæsthesia" and of fainting are examples of this fact.

Sensory paralysis is also one of the earliest and most potent factors in general anæsthesia, and occurs, according to Anstie, as follows. "It will be found, in the great majority of cases, that it commences in the posterior extremities (at least in vertebrated animals), and advances slowly, engaging successively the parts supplied by nerves more and more from the anterior portions of the spinal cord." As showing the relation of loss of consciousness to sensory paralysis the following observation of Anstie is pertinent: "The main difficulty of tracing accurately the comparative course of the sensory paralysis produced by different narcotics is, that, in the case of those which affect the brain powerfully, unconsciousness arrives so early as to vitiate the investigation, unless the circumstances of the experiment are particularly favorable."

It is probable that in the usual depth of surgical narcosis, quiescence of the motor apparatus is for the most part dependent upon these two conditions, loss of consciousness and sensory paralysis. Numerous facts are observed during operations under general anæsthesia which show that the motor parts of the nervous system are not incapable of response to direct stimulation at that time; in fact, from the vigor of the action thus caused, it would seem that they are but slightly affected. Of these facts the following are the more common: In deeply anæsthetized subjects, violent muscular action is evoked by irritation or section of the motor nerves. Examples of this are found in the twitching of the muscles of the face which not infrequently occurs in mastoid operations from irritation or injury of the facial nerve in the Fallopian canal, and in similar movements of the muscles of the back and arm from injury of their nerves during extensive breast operations. Electrical excitation of the phrenic nerves results in powerful movements of the diaphragm, even in the most alarming depths of narcosis. The various motor centres of the brain are capable of causing movements in the parts they control upon proper excitation during deep anæsthesia, and all of the phenomena of epileptic seizures may be induced in certain epileptic subjects (particularly in cases of traumatic origin) by such irritation of the area corresponding to the part in which the motor manifestations of a paroxysm begin. Ankle clonus and many similar motor reflexes frequently occur from certain positions of the parts in completely anæsthetized subjects. These and other examples of the non-paralyzed condition of the motor nervous apparatus, in complete and even deep anæsthesia, would seem to confirm the opinion that the action of the narcotic is chiefly upon the sensory parts and those governing consciousness.

As has been seen, the last portion of the nervous system to be overcome by the paralyzing influence of anæsthetics is the medulla, and it follows that respiration and circulation are thus maintained after practically all other body functions have been abolished. Joseph Coats has clearly stated that: "The object of an anæsthetic is to suspend the action of the nerve centres which have to do with sensation and motion while leaving the respiratory and cardiac centres intact. It is not surprising that these latter centres, which continue under all circumstances throughout life their rhythmic action, should be more resistant than others, and that they should persist in their function after other centres have succumbed. We may expect, however, that any agent which suspends the function of the centres of sensation and motion will have some effect on those of the respiratory and cardiac centres, and there is abundant evidence to show that all anæsthetics which produce their action by being introduced by some method into the blood are capable of affecting both the respiratory and the cardiac centres."

It is now a proper time to consider the action of anæsthetics upon the respiration and circulation.

Action on the Respiration.—In the early stages of the induction of anæsthesia the respiration takes part in the general stimulation or excitation which is usually present at this time. We therefore observe an increase in the rate, depth, and vigor of the respiratory movements. As narcosis appears these subside, becoming progressively shallower and shallower as the action of the anæsthetic increases, and finally ceasing altogether after a period of irregularity as the medulla is paralyzed. These statements refer to the simple action of anæsthetics upon the function of respiration, and do not take into account the complications which arise from certain states of the circulation and from alterations in the supply of oxygen, as met in actual practice.

The effect of these factors will be considered in the following paragraph, and later under the heading, Phenomena of Anæsthesia.

Action on the Circulation.—The maintenance of the circulation depends upon the integrity of a number of factors: the action of the heart, its nervous control, intrinsic and central, the tone of the vaso-motor mechanism, and the continuance of the respiration. Anæsthetics are apparently capable of affecting the circulation through each of these, and the matter is consequently a complex one. An administration so conducted as to produce uncomplicated narcotism, gradually increased till death, would cause the following changes in the circulation: After a period of stimulation, in which the heart's action was increased in rate and force, it would subside to normal and below; the blood pressure, at first elevated, would fall from vaso-motor paralysis and cardiac enfeeblement, and with stoppage of the respiration the heart would suffer from the withdrawal of this effective aid in maintaining the circulation, from the resistance due to stoppage of the circulation in the lungs and from non aeration of the blood. Already influenced by the increasing paralysis of the medulla and its own intrinsic ganglia, the heart's action would now become more and more inefficient, and would cease after a period of irregularity.

Such, in brief, would seem to be the mode of action of anæsthetics on the respiration and circulation, but clinical experience has furnished an abundance of facts indicating that under certain conditions this sequence of events may be strikingly altered. Deaths have occurred at all periods of the narcosis, in many instances before loss of consciousness and from but a few "whiffs" of the anæsthetic. Some of these cases have presented primary

failure of the respiration, but in others the circulation has distinctly failed first. In the hope of clearing up these points, numerous experimental investigations have been undertaken, notably those of the Royal Medical and Chirurgical Society of London, the Glasgow committee of the British Medical Association, the Hyderabad Chloroform Commissions, as well as those of Reichert, Wood, MacWilliam, Gaskell, Shore, Hare, Hill, and others. These investigations all relate to the action of anæsthetics, particularly of chloroform, on the circulation and respiration; and while on many points they are in perfect accord, there is great difference of opinion as to whether deaths from anæsthetics are due primarily to action on one or the other of these functions, some contending that the respiration invariably fails first, others that the heart may be directly paralyzed and fail before the respiration. The conclusions of the Hyderabad Chloroform Commissions on this point are thus clearly expressed:

"The inhalation of chloroform vapor, no matter in what doses or in what manner carried out, cannot kill a dog by acting directly upon its heart. We must invariably affect the nervous mechanism of respiration before involving the cardiac centres of the medulla oblongata or affecting the contractions of the ventricles and auricles to any extent The commission further consider that chloroform vapor administered to dogs never kills by acting on the intracardiac ganglia either primarily or secondarily. It is impossible to produce syncope from chloroform in dogs. The commission are of the opinion that in the dog the danger to life from chloroform inhalation arises only when the cells of the respiratory centres (both respiratory and expiratory) of the medulla oblongata have their functions interfered with."

These positive assertions of the first Hyderabad Chloroform Commission were the outcome of carefully and ably conducted experiments on one hundred and forty-one dogs in the year 1888. They were so opposed to clinical evidence and to the results of the experiments of the Glasgow Committee and others, that their deductions were not generally accepted as applicable to man. A second Hyderabad Chloroform Commission was held in the following year. The experiments numbered five hundred and eighty-eight. They were conducted chiefly upon dogs and monkeys on thoroughly scientific principles and "were designed to show the effect upon the blood pressure, heart, and respiration of the inhalation of chloroform, ether, and the A. C. E. mixture, administered in various ways and under varying conditions" The results of this commission were the same as those of the first, and the following conclusions relative to the action of anæsthetics upon the respiration and circulation are sufficient for the present purpose:

"Chloroform, when given continuously by any means which insures its free dilution with air, causes a gradual fall in the mean blood pressure, provided the animal's respiration is not impeded in any way, and it continues to breathe quietly without struggling or involuntary holding of the breath, as almost always happens when the chloroform is sufficiently diluted. As this fall continues, the animal first becomes insensible, then the respiration gradually ceases, and lastly the heart stops beating. If the chloroform is less diluted the fall is more rapid, but is always gradual, so long as the other conditions are maintained; and however concentrated the chloroform may be, it never causes sudden death from stoppage of the heart. The greater the degree of dilution the less rapid is the fall, until a degree of dilution is reached which no longer appreciably lowers the blood pressure or produces anæsthesia. If the administration of the chloroform is stopped at an early stage, the pressure very soon begins to rise again, and gradually becomes normal; but if the chloroform is pushed further, there comes a time, not easy to define, when the blood pressure and respiration will no longer be restored spontaneously, although the heart continues to beat after the inhalation is stopped. . . . Complete stoppage of respiration always means that an overdose has been administered."

The experiments of this commission with ether were few and unsatisfactory.

Laurie, who was a member of both Hyderabad chloroform commissions, has very concisely stated his views on the action of chloroform relative to the respiration and circulation as follows:

"1. During the first stage (from the commencement of the inhalation to the point where anæsthesia is complete) chloroform narcosis affects primarily and immediately the vaso-motor centre. This dilates the arterioles, and the blood pressure falls continuously throughout, and as the narcotic action of the chloroform increases, consciousness is abolished, the reflex functions of the brain and spinal cord, other than those necessary to sustain life, are also abolished, and the period terminates with complete anæsthesia, with or without some narcosis of the respiratory centre. We all know that sometimes before anæsthesia is complete, stertorous breathing is set up.

"2. During the second stage (between the point of complete anæsthesia and stoppage of the respiration), while the narcosis of the vaso-motor centre continues and becomes fully developed, the respiratory centre is gradually completely narcotized. During this stage, the fall of the blood pressure is due in the first instance to the completion of vaso-motor narcosis, and in the second to weakening of the heart from narcosis of the respiratory centre and failure of the respiration. It is not possible to say exactly when the vaso-motor fall ends and the cardiac fall begins; a great deal will depend on the strength of the heart at the beginning of the period at which narcosis of the respiratory centre sets in.

"3. During the third period (from the point of stoppage of the respiration to death from failure and stoppage of the heart), the respiration having ceased, the nutrition of the heart fails, and with completion of cardiac failure the blood pressure falls too, and terminates in death at zero. Death is not due to asphyxia or to syncope, but to failure of the nutrition of the heart after stoppage of the respiration just as it is in bullet wounds of the brain."

Brunton, who was a member of the second Hyderabad Chloroform Commission, has thus expressed his opinion on the points under consideration: "I have stopped the pulsations of an animal's heart by blowing chloroform vapor directly into the lungs. But what I wish to maintain is, that notwithstanding all this, when chloroform vapor is inhaled in the usual way by inspiratory efforts of the patient himself it does not stop the heart, but first acts upon the respiratory centre, and, by stopping the breathing, prevents a quantity of chloroform sufficient to stop the heart from reaching that organ."

The elaborate experiments of MacWilliam followed closely those of the Hyderabad Chloroform Commission, and his conclusions, from experiments performed mostly on cats, are at considerable variance with theirs. A number of the more important ones are as follows: "During chloroform anæsthesia the blood pressure is lowered and the heart's action is weakened. Dilatation of the heart occurs to an appreciable extent, even when chloroform is administered gently, mixed with abundance of air (under four per cent. of chloroform vapor in the air). Dilatation may occur even before the conjunctival reflex is abolished. The dilatation affects all parts of the heart, more or less—the left side as well as the right. It is not due to changes in the pulmonary circuit. The dilatation is not due to the accompanying fall of pressure, to the diminished resistance to the ventricular systole, or to the diminished blood supply through the coronary arteries. Dilatation does not result from a similar fall of pressure brought about by means other than chloroform—for example, arterial relaxation caused by section of vaso-motor nerves. Dilatation under chloroform often occurs very quickly, before there is any fall of pressure. Moreover, when the dilatation has followed a fall of pressure, it is not removed by artificially raising the pressure—for example, by compression of the abdominal aorta. There is no distinct change in the rate of the heart's

action when dilatation occurs. A sudden and complete cessation of the cardiac rhythm is never caused by the inhalation of chloroform. Cardiac failure occurs by a more or less sudden enfeeblement and dilatation of the organ, not by a sudden complete cessation of rhythm. The tone of the heart muscle is depressed, the cardiac walls become relaxed, and the functional efficiency of the organ is impaired. When the heart becomes greatly dilated it fails to be an effective force in keeping up the circulation, while its rhythmic movement still continues—though so feebly as to be inefficient. Cardiac failure sometimes occurs in this way a considerable time before the respiration stops, though generally the respiration stops before the heart has become incapacitated. The depressing influence of chloroform on the heart—leading to dilatation of its cavities—is not exerted through the vagus nerves, but is a direct effect of the drug upon the cardiac mechanism. Section of both vagi does not obviate the weakening and dilating influence of chloroform upon the heart. The weakening and dilating effects of chloroform are sometimes manifested in tolerably equal degrees on both auricles and ventricles; but sometimes more readily upon the auricles, and at other times upon the ventricles.

"The contrast between the relation to the heart's action of chloroform and ether in anæsthetic doses is very marked. With chloroform, cardiac dilatation frequently occurs—and often, indeed, a very marked dilatation—before the conjunctival reflex is abolished. With ether, the induction of anæsthesia with complete abolition of the conjunctival reflex has not been attended by any noteworthy dilatation; indeed, effects of a stimulating character have sometimes been observed, and the peculiar periodic ventricular depression sometimes following chloroform has been seen to be removed. The occurrence of fibrillar contraction (delirium cordis) does not appear to be a primary mode of cardiac failure from the inhalation of chloroform in the healthy animal, though it may sometimes supervene when the heart has become distended and incapacitated by chloroform. The fall of blood pressure under chloroform is in its earlier stages due mainly to the depressing effect of the anæsthetic on the vaso-motor centre, preceded often by a slight stimulation; the later stages are associated with failure of the heart as well as of the vaso-motor centre. The relative occurrence of cardiac dilatation and vaso-motor depression varies. Sometimes the heart begins to dilate early—before there is any fall of pressure, at other times a large fall of pressure may occur before cardiac dilatation becomes marked. In certain circumstances, when chloroform is very suddenly taken in, a dangerous dose may be absorbed, and the heart may become seriously affected *before* the vaso-motor centre has had time to be much depressed."

H. C. Wood has taught for years: "First, that although ether in moderate doses acts as a stimulant to the circulation, yet, in overwhelming amount, it is capable of depressing the heart; but that such depression of the heart is always less than the depression of the respiration, and therefore ether kills always through the respiration. Secondly, that chloroform may produce death by paralysis of the respiratory centre, or by a simultaneous arrest of respiration and circulation, but that primary paralysis of the heart may occur, and is especially prone to do so when the chloroform vapor has been given in concentrated form."

Reichert, Wood, and Hare agreed that "chloroform is a cardiac paralysant and often does kill dogs by a direct action upon the heart or its contained ganglia." The conclusions of the Hyderabad Chloroform Commissions induced the two last named to restudy the subject, with the result that they "definitely proved that in the dog chloroform has a distinct, direct, paralyzing influence on both respiration and circulation; that the respiration may cease before the heart-beat, or the two functions be simultaneously abolished; but that in some cases the heart is arrested before respiration. We have several times seen the respiration continue as long as one, and even two minutes after the blood pressure has fallen to zero, and the pulse has completely disappeared from the carotid artery. . . . In a series of experiments I have recently made myself [Wood] to determine the changes in the circulation produced when ether anæsthesia is carried on to death, I have found that in the first periods of anæsthesia the blood pressure is usually elevated, and that it is usually quite high at the time when the respirations are very shallow and imperfect, and the dark color of the blood shows that it is heavily charged with carbonic acid. It is not, however, very rare for the blood pressure to remain near the normal, and I have seen the blood pressure begin to fall in the very first stages of ether anæsthesia; moreover, in at least two experiments, death occurred from syncope, the respiration continuing for one or two minutes after the complete cessation of the respiration. . . . So far, then, as concerns the method in which ether and chloroform kill, I claim most urgently that there is no contradiction between the results as obtained by the bedside and in the physiological laboratories, and that a complete, broad study of the clinical and experimental evidence leads to one conclusion, namely, that chloroform and ether are capable of paralyzing the respiration and the circulation; that in some cases one function, in other cases the other function, is primarily arrested; but that ether is less prone to produce a primary arrest of the heart than chloroform."

Leonard Hill has made a large number of valuable experiments and observations on the action of anæsthetics with reference to the respiration and circulation, the result of which is indicated by the following conclusions:

"Chloroform acts upon three parts of the economy: (1) the heart, (2) the respiratory centre, (3) the arterioles. By its action on the arterioles, chloroform does not produce directly fatal results, but inasmuch as it dilates these, it lowers the blood pressure and produces anæmia of the respiratory centre. This is a most important factor in regard to the stoppage of respiration. . . . The action of chloroform upon the respiratory centre is twofold. It is partly indirect, as we have just stated, and partly a direct action of the chloroform itself upon the centre. Arrest of respiration will be most easily produced when both these conditions of anæmia and chloroform act together on the centre. If the centre be much damaged by anæmia, far less chloroform will arrest its action than when it is well supplied with blood. And both these conditions are present during prolonged anæsthesia. This is the explanation of death from respiratory failure after chloroform has been administered for some time. Partly from the shock of operation, partly from the prolonged action of chloroform on the heart and arterioles, the circulation through the respiratory centre has been ebbing and ebbing until the centre is no longer able to bear up under the degree of anæmia so produced, combined with the depressing effects of the amount of chloroform which happens at that moment to be administered. Thus the respiration ceases. . . .

"But the action of chloroform upon the heart is a much more serious matter. When chloroform dilates the cavities of the heart, the power required to empty them increases as the cube of their radius, yet at the same time the power of the poisoned muscle is directly diminished. There are thus two factors acting in the arrest of the heart: (1) the distention of its cavities and (2) the direct weakening of its muscle."

In the cross-circulation experiments of Gaskell and Shore, in which the brain of one animal was supplied with blood from another, whereby "chloroform could be sent to the vaso-motor centre without being sent to the heart, or to the heart without reaching the vaso-motor centre, it was shown that the vaso-motor centre was not, at any rate at first, depressed by chloroform, while the heart was primarily affected, and that this weakening was the cause of the fall of blood pressure." Kirk has advanced a theory, accounting for "primary chloroform syncope," of which he has given this brief description: "The way to produce the primary syncope with certain anæsthetic vapors, more especially with such chlorine compounds as bichloride of methylene and chloroform, is to charge

the air in the lungs with a certain proportion of the vapor of these substances. to allow it a short time to act, and then to let it escape by permitting the patient to breathe fresh air. The escape of the vapor under these circumstances is immediately followed by a violent reaction in the circulation, attended with a dangerous liability to syncope; this reaction, in fact, does lead to syncope in numerous instances, and the syncope so induced may prove fatal." He further refers to this reaction as a "reverse movement of the reflex mechanism," and states that "here is to be found the solution of the enigma of chloroform syncope and of all supposed anomalies in the action of chloroform."

The investigations referred to, and many others of which the limitations of this article will not permit mention, seem to prove that anæsthetics are capable of dangerously affecting the heart by reason of their direct action upon it.

The local action of anæsthetics upon the lungs has received considerable attention. The Glasgow Committee noted the fact that "chloroform, when administered by the lungs, produces, as a direct local action, such a change in the walls of the vessels as to cause . . . a retardation and stoppage of the circulation in the lungs, first in the capillaries, then in the arterioles, and subsequently in the larger vessels"; in this way acting as an obstruction to both respiration and circulation.

Holscher has arrived at the following conclusions regarding the action of ether upon the lungs: "Aside from a slight increase of mucous secretion, ether vapor has no other irritative action on the tracheo-bronchial mucous membrane. The glistening appearance of the bronchial and tracheal epithelium is not altered during narcosis."

The action of anæsthetics on the kidneys has been extensively studied both clinically and experimentally. Clinically it has been shown that in the deeper degrees of anæsthesia the urine is more or less suppressed and contains albumin in a considerable percentage of cases. Weir has reported observations on the urine in 34 carefully selected cases, excluding operations upon the abdomen and the genito-urinary organs. All were free from albuminuria before etherization, afterward 9 presented a trace of albumin, the remaining 25 being unchanged. In 5 cases presenting evidence of diseased kidneys before operation, there was no increase of albuminuria in 3, slight increase in 2 after etherization.

Legrain found albuminuria in 10 out of 54 persons after chloroform and in 12 out of 41 after ether. From experiments on dogs this writer considered that the effects of chloroform upon the kidneys were more lasting than those of ether. Popoff found occasional transient albuminuria after ether, but in 140 carefully observed cases he saw no permanent damage even in those with evidence of kidney disease before the administration.

Patein noted transient albuminuria after chloroform in one-third of the cases observed.

Thompson and Kemp, in some elaborate experiments on the "effects of different anæsthetics on the kidneys," arrived at the following conclusions: "As regards ether, it would appear that this agent produces a *special contraction of the renal arterioles*, with a consequent damaging effect upon the renal secretory cells, similar to those which follow clamping the renal artery. The kidney shrinks in bulk, with consequent fall of the oncometric tracing, and accompanied by diminution of secretion, marked albuminuria, and, finally, suppression. . . . This condition of the kidney is not due to any change in the general arterial circulation, since it occurs not only when pure ether is administered, but also in the mixtures in which it is a constituent, if the semi-closed or closed method is employed. . . . The effect of chloroform upon the kidneys seems to be *nil*. The oncometric curves are nearly normal, and are affected only through sharing in general circulatory changes. The secretion of urine continues up to the last moment of life, and the albuminuria is so slight that its presence at all is apparently due only to respiratory interference."

Chloroform mixtures containing ether were found to affect the kidneys in the same manner as chloroform, if administered by the open method, as ether if by the closed method. Popoff, Schiff, Knoll, and Wunderlich believe that the renal disturbances accompanying etherization are due "to general vaso-motor disturbance, and not to local kidney changes."

In healthy kidneys chloroform is said to cause albuminuria more frequently than ether, while in diseased kidneys the use of ether is said to be more dangerous than chloroform.

These renal disturbances after anæsthesia are in direct proportion to the amount of the anæsthetic the patient receives. The researches of Parasporo, Thiem, Fischer, Schenk, and others show that both ether and chloroform, particularly in their prolonged administration, are capable of causing degenerative, inflammatory, or necrotic changes in the internal organs.

A destructive action of anæsthetics upon the blood corpuscles has been disproved, at least in the case of ether, by the investigation of von Lerber. "In 101 cases the blood was examined and the hæmoglobin was, in the majority of instances, unaltered; the corpuscles were found to be but little changed either in number or in appearance, although some leucocytosis was present. Spectroscopic examination of the urine showed no increase of urobilin." He concludes, therefore, that ether does not exert any deleterious effect upon the blood, as claimed by Hermann, Da Costa, and others. The body temperature under anæsthetics has been studied by Kappeler, Bert, Hare, and others. Kappeler found that with ether and chloroform a slight rise of temperature was often observed during the stage of excitement. Later, the temperature fell from 0.2° C. to 1.1° C. under chloroform, and from 0.3° C. to 1.5° C. under ether.

According to the researches of Angelesco the temperature falls "during the whole time anæsthesia lasts. The variation in temperature is most marked during the first and second fifteen minutes. The temperature fall continues, though slight, during the deep sleep following anæsthesia. Temperature begins to rise at the moment of waking."

The anæsthetics are eliminated almost entirely by the breath. Small quantities of chloroform have been found in the urine and milk after anæsthesia.

The Phenomena of Anæsthesia.—These depend, for the most part, upon the successive involvement and final paralysis of the different parts of the nervous system. Narcotics which act rapidly, as nitrous oxide, allow few phenomena, while slow-acting agents, as alcohol or opium, furnish a great many. Ether and chloroform occupy an intermediate position in this respect. While these phenomena are modified greatly by the rapidity with which the anæsthetic is administered, their sequence, in usual cases, is marked by several prominent physiological changes, according to which the narcosis has been divided into degrees or stages. Of these terms, "degrees" is the better, for, as Snow has pointed out, "the slighter degrees of narcosis occur in the later stages of the process, during the recovery of the patient, as well as in the beginning."

Although different authorities variously divide narcosis into from two to five stages, the four as described by Hewitt present the most distinct limitations. Briefly outlined they are as follows: 1. The period of conscious inhalation. 2. The period of unconsciousness with imperfect anæsthesia. 3. The period of perfect anæsthesia. 4. The period of excessive and dangerous narcosis. The phenomena of these periods, briefly stated, are as follows:

1. *The Period of Conscious Inhalation.*—The odor of the agent is first appreciated, and if it be pungent and strong, the regularity of the respiration will be interrupted by delayed, hesitating, and imperfect inspirations, closure of the glottis, swallowing movements, choking, cough, smothering and suffocative sensations with consequent fear, struggling, and resistance. After a few respirations the following may be experienced: general exhilaration and warmth, fulness in the head, buzzing or ringing in

the ears, dizziness, exaggeration of hearing (rendering normal sounds excessive), flashes of light, numbness, tingling, and a feeling of weight and stiffness in the extremities, emotional feelings, sinking sensations, and a feeling of impending unconsciousness. Increased flow of tears and saliva is common in this stage, due most likely to the pungency of the vapor.

The pulse at this time depends more upon the mental state of the patient than upon any action of the anæsthetic. The rapid heart's action commonly noted is due to nervousness or fright, and if the latter is excessive, more or less shock may be present, with rapid, small pulse, pallor, and prostration.

The respiration is usually normal except as above noted. The pupil is variable, being affected by other things than the anæsthetic. Dilatation of the pupil is not uncommon at this time, particularly in nervous, apprehensive patients.

2. *The Period of Unconsciousness with Imperfect Anæsthesia.*—Consciousness is lost suddenly, as a rule, and at about the same time disordered cerebration becomes manifest through delirious expression and action, including laughing, crying, irrational talking, shouting, singing, hallucinations of sight and hearing, struggling, fighting, etc. These manifestations may increase to a certain point and then subside gradually or suddenly; speech becoming more and more incoherent and inarticulate, and finally ceasing after a period of mere phonation. Muscular action becomes more and more incoordinate, and a period of general muscular rigidity of a tonic character frequently precedes the final relaxation. Occasionally, clonic movements and tremors occur during this period.

There is usually an increased flow from the lachrymal and salivary glands. The pulse becomes full, bounding, and rapid, often reaching the rate of 140 or 160, and, under chloroform, often presents considerable irregularity. The blood pressure is increased and the body temperature elevated. The color is heightened, especially about the face, neck, and chest, and a bright red spotted rash (similar to the eruption of measles) not infrequently appears on these parts from ether, and has been called the "ether rash." Profuse perspiration is common. The respiration, sharing in the general excitation, becomes exaggerated, often excessively, and is liable to some degree of obstruction from one or more of the following causes: (1) Stertor; (2) stridor; (3) rigidity of the respiratory muscles; (4) valve-like action of the pharynx, cheeks, lips, and nostrils; (5) foreign matter in the air passages.

(1) The stertor present at this time is usually of a reflex character and is frequently associated with deprivation of oxygen from too rapid administration.

(2) Stridor is also reflex and is due to spasmodic closure of the glottis. It may be caused by the pungency of the vapor or other irritation.

(3) The respiratory muscles may take part in the general tonic muscular rigidity, to the extent of preventing the respiratory movements more or less completely, and alarming asphyxial states may be brought about in this way. This phenomenon is usually associated with too rapid administration of the anæsthetic and consequent limitation of air.

(4) Mechanical obstruction to respiration may result from valve-like action of the pharynx, cheeks, lips, and nostrils, favored by the vigorous respiration present. If the oral airway is obstructed by reason of closure of the jaws, the presence of perfect teeth and rigidity of the lips and cheeks, the nasal apertures will often be inadequate to the rush of air on inspiration and the normal action of the dilator muscles of these orifices will be overcome by the resulting suction force. The alæ nasi will be drawn together, and there is then a tendency to the production of a vacuum in the cavities of the nares, the mouth, and the pharynx on inspiration. In consequence of this the tongue, the epiglottis, and the walls of the pharynx are drawn together over the laryngeal opening, and complete mechanical obstruction may thus be brought about, favored by the hyperæmia and swelling of all of these parts which take place at this time, as pointed out by Hewitt. Obstruction to expiration is often observed at this stage. It is the result of closure of the mouth and forward movement of the tongue against the teeth, coupled with a valve-like action of the soft palate resulting in closure of the naso-pharyngeal airway. This produces a puffing form of expiration accompanied by blowing up of the cheeks and not infrequently by expiratory stertor. Muscular rigidity of the parts in question plays a prominent part in these forms of respiratory obstruction. The jaws are often set by spasm of the masseters, the cheeks rigid, and the lips firmly closed or pursed up by muscular action.

(5) Mucus and saliva—which are formed freely in this period—often produce some degree of obstruction to respiration by being drawn into the larynx and trachea. The same is true of products of vomiting which may occur at this time. Duskiness or cyanosis appears in proportion to the amount of obstruction produced in these various ways. During this period the reflexes are active, although in its later stages they become sluggish. The pupil is variable. There is a tendency toward dilatation in the early, and toward contraction in the later stages of this period.

As the narcosis deepens, these phenomena of excitation subside. The muscles relax, the pulse and respiration assume more normal characteristics, anæsthesia becomes complete, and the patient passes into the third period of narcosis.

3. *The period of perfect anæsthesia* is characterized by complete muscular relaxation; by absence or marked sluggishness of the lid and of conjunctival or corneal reflex; by a state of the pupil which under ether is somewhat dilated, under chloroform somewhat contracted, and the reaction of which to light is sluggish or absent; and by a state of the respiration and circulation not markedly different from normal, the respiration being inclined to stertor of a palatine or snoring character. In the early stages of this degree the sensibility of ordinary parts is abolished, but certain special localities, as the anus, perineum, bladder, matrix of great toe nail, etc., are not incapable of causing reflex response to irritation and are only overcome in the more advanced stages.

The body temperature is lowered, the heightened color lessens, and the spotted rash of ether becomes confluent.

4. *The period of excessive and dangerous narcosis* is characterized by dilated and fixed pupils, entire absence of conjunctival or corneal reflex, a half-open condition of the eyelids, and gradual failure of the respiration and circulation. As this period approaches, the respiration frequently takes on a gasping character, with very quick, short inspirations, each of which is accompanied by a downward movement of the lower jaw causing the mouth to open. This is the form of breathing usually seen in nearly all dying persons and is distinctly characteristic of impending death. The breathing may, however, simply become more and more feeble, shallow, and irregular; it may be rapid or slow, and it may cease gradually or suddenly. The pulse is usually slowed in this period, although it may remain rapid. It gradually loses volume and strength, and before ceasing becomes irregular and intermittent. If this degree of narcosis has been brought about slowly, the pulse persists till after respiratory failure has become complete. It is then rapidly affected by the resulting asphyxia.

This general account of the phenomena of anæsthesia is based upon a gradual and uncomplicated administration. It has been elsewhere shown that if this is too rapidly conducted, an overwhelming effect upon the respiration or circulation may be produced suddenly and without reference to the usual succession of signs. While the phenomena above noted are those of narcosis in general, the different anæsthetic agents possess individual peculiarities of action which serve to make their narcosis characteristic. The narcosis of nitrous oxide is characterized by the great rapidity with which complete anæsthesia is established, the apparent absence of stages, the

scarcity of phenomena, the lack of muscular relaxation, and the great tendency to the production of asphyxial states. The narcosis of ether is characterized by phenomena of irritation and stimulation, by a moderate tendency to the production of asphyxial states, and by the marked absence of phenomena of depression as compared with chloroform. The narcosis of chloroform, as compared with that of ether, is characterized by the absence of irritation and stimulation, by a tendency to the production of mechanical asphyxia, and by the occurrence of phenomena of depression.

(For details of the administration of the general anæsthetics for surgical purposes, the reader is referred to the author's article on *Chloroform, Ether, and Other Anæsthetic Agents, Administration of.*)

Thomas L. Bennett.

ANÆSTHOL.—This is an anæsthetic recently introduced by Willy Meyer, of New York, to replace the A.C.E. mixture. He mixes chloroform and ether in molecular proportions, *i.e.*, 43.25 per cent. of chloroform and 56.75 per cent. of ether by volume, and calls the mixture "M. S." Of this he takes 83 volumes, and adds to it 17 volumes of ethyl chloride. The mixture has a boiling point of 40° C. (104° F.), and would seem to be open to the objection urged against the A. C. E. mixture, that constituents of different volatilities do not volatilize equally. We might expect the ethyl chloride to vaporize more rapidly than the ether, and this more rapidly than the chloroform. *W. A. Bastedo.*

ANAKHRE. See *Goundou.*

ANAPHRODISIACS.—This is a term applied to agents which are used to lessen an immoderate or morbid sexual desire, but the treatment must be of wide scope and include the moral, dietetic, and hygienic management of the case, while not infrequently surgery must be called upon. The causes of aphrodisia are many, and not the least important is reflex irritation of the genitalia, caused by physical peculiarities or deformities, phimoses, strictures of the urethra, diseases of the prostate, chronic constipation, fissures or hemorrhoids of the anus, eczema, highly concentrated urine, etc. In other cases the reflex irritation may be caused by the presence of worms in the rectum or in the vagina, in the case of female children, and by excessive exercise causing friction of the thighs in young children (horseback riding, bicycle riding). These conditions will each call for its own special treatment in addition to the general measures which should be adopted; for the detection and relief of the exciting cause are difficult problems and far more important than the exhibition of drugs. For another class of patients, those suffering from diseases of the nervous system or those with psychical perversion, the essential of treatment is confidence in the physician, on the part of the patient, and suggestion, hypnotic or otherwise. Many authenticated cases have been recorded of permanent cures based upon the treatment by suggestion, and it is invaluable in cases of neurasthenia.

In general, for the treatment of aphrodisia nothing will be found better than physical and particularly mental work to the point of fatigue. The latter accomplishes its results in two ways: first, by exhausting the brain where the sexual impulse (if not reflex) has its origin; and secondly, by so absorbing the patient's interest as to preclude the occupation of his mind by lascivious thoughts, pictures, and mental impressions. The anaphrodisiac effect of mental activity is easily explained when we consider the large amount of nervous energy which accompanies each conjugal act.

In the general management of a case the physician should advise a non-sedentary life, as much as possible in the open air, light diet, with an absence of meats, coffee, highly seasoned foods, and alcoholic stimulants; the kidneys should be kept well flushed, the bowels well open, and the patient should sleep on a hair mattress, with light covering, in a cool, well-ventilated room. As a full bladder is frequently a cause of irritation, it should be emptied upon going to bed and the first thing in the morning. The patient should arise early and take a cold douche or sponge bath. The only mechanical contrivance which seems to be of much benefit is one that will prevent the patient from sleeping on his back, and for this purpose a towel knotted at the back may be used. The insertion of rings in the prepuce or labia and the local application of caustics are to be condemned. Drugs which may be used are the bromides, gr. x. to xx. three times a day, and antimony, chloral, salicin, conium, and other depressants; nauseants may be used with care, and are effective sometimes. *Charles Adams Holder.*

ANAPLASIA.—This word is used by some writers synonymously with anaplasty, having the meaning of a repair of injured parts by means of plastic operation. In 1893 its use in an entirely different sense was introduced by Hansemann, who wished to designate by some specific term the morphological and physiological differences which exist between the cells of malignant tumors and those of the normal parent tissue.

The type and character of the parent cells are usually preserved to some extent in the tumor cells which arise from them; as, for example, the cells of a squamous-cell carcinoma of the skin may undergo a horny change; those of an adeno-carcinoma arising from cylindrical cells are more or less cylindrical in shape; the cells of an adeno-carcinoma of the thyroid may produce a colloid-like substance; metastases of an adeno-carcinoma of the liver may secrete a bile-like fluid; and the sarcomata arising from the chromatophores of the skin produce melanin. These resemblances of tumor cells to their parent cells are not so marked as the differences which exist between them, both in morphological and physiological characteristics. The latter are shown by striking variations in size and form; by changes in the finer structure of the nucleus and cell body as shown by staining reactions (hyperchromatosis, hypochromatosis, etc.); by abnormal cell-division forms; by the changed chemical character or total absence of cell function; and by the tendency to undergo degeneration. To all of these alterations in cell character which constitute malignancy Hansemann would apply the term anaplasia, as opposed to heteroplasia and metaplasia. According to his view, the significance of these changes must be that the cells of malignant tumors have lost in differentiation and so have acquired the power of individual existence. The manner in which the cells have undergone this change or the etiology of malignant tumors is not included in the meaning of the term. There can be no doubt that the use of the term anaplasia in this application is of great service; and though Hansemann's views have met with much opposition, it has gained a wide acceptance in modern pathology. *Aldred Scott Warthin.*

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ANASARCA. See *Circulation, Disorders of.*

ANATOMY, HISTORY OF.—Considering the necessity of the anatomical sciences as a basis for the proper study of the healing art, and the high position assigned them in modern times, it may seem strange that their early development was slow, and the knowledge of the ancients concerning the structure of the human body crude and superficial. The principal cause of this was the prevalence of animistic ideas, it being thought that spirits inhabited or controlled the body in some mysterious way. Involuntary movements, such as the pulsation of the heart and arteries, the twitching of muscles, the phenomena of respiration and bodily heat, were all considered indubitable signs of the presence of such spirits, to which were ascribed most cases of disease and disordered action.

After leaving the body the spirit was thought to main-

tain some occult relation to it. Hence the corporeal remains were either preserved with pious care, or burned or entombed to prevent their suffering insult or injury that might affect the career of the spirit in the other world. Mingled with these superstitious ideas were others derived from horror of death and repulsion from corrupting flesh. Contact with a dead body was usually held to be a defilement requiring long purification, and to attempt to inspect its internal structure was a sacrilege meriting the severest punishment. Dissection was, under such circumstances, practically impossible. It is certain that but few writers of antiquity were able to avail themselves of this method of research.

The sources of information were therefore indirect. Animals killed either for food or sacrifice, the occasional examination of persons severely wounded or suffering from eroding diseases, the noting of the effects of putrefaction which displayed the deeper structures, especially the bones, were the usual means employed for the investigation of the human body. In Egypt, it is true, bodies were eviscerated for the purpose of preserving them as mummies; but this appears to have been done by a low class of servants under the direction of priests who regarded the interests of the spirit in the other world as the only essential, and who therefore gave no thought to exact anatomical knowledge.

Yet among the ancient Egyptians are found some of the earliest attempts at recording anatomical data. The Ebers papyrus, of about 1550 B.C., and said to be the oldest complete book extant, relates to the healing art and contains incidental allusion to the structure of the body. Vessels and nerves are together designated as "metu"; of which four are distributed to the nostrils, four to the temples, four to the head, two in each hand and foot, etc. The heart is regarded as the centre of the vascular system, and vessels containing blood, air, water and other fluids pass from it to all parts of the body. Vital spirits are said to enter one nostril and penetrate to the heart; an idea which was to have a great effect upon anatomy and physiology as far down as the seventeenth century. Similar determinations, of no greater value, are found in papyri of a somewhat later date.

Contemporary with the Egyptian culture, or possibly anterior to it, was that of Chaldæa and Assyria from which the Phœnicians and Hebrews derived much. One of the contributors to the Ebers papyrus is stated to be from Byblus, a town of Phœnicia. Certain cuneiform inscriptions indicate that the situation of the vessels of the neck was known, as they describe the compression of these structures to relieve the pains of circumcision.

The anatomy of the Hebrews was probably derived mainly from Chaldean, Assyrian, and Egyptian sources. The principle of life was believed to reside in the blood (Gen. ix. 4; Lev. xvii. 11), which was accordingly forbidden as food and used as a propitiatory offering. The heart was supposed to be the seat of the understanding, courage, and love; to dilate with joy, contract with sadness, harden or soften with the passions. These expressions, which have become wholly figurative in modern times, were formerly believed to be literally true. The later Talmudists had some anatomical knowledge of the female genitalia, the œsophagus, the lungs, the kidneys, the spinal cord, and the cauda equina. One of the rabbis, at the close of the first century, is said to have boiled a body for the purpose of obtaining the skeleton. A fabulous bone, "luz," was thought to become the seed of the body from which it is to be renewed at the resurrection.

The early writings of India contain no anatomical knowledge except names of a few parts of the body. Somewhat later (900–200 B.C.) there are rude attempts at the enumeration of structures. To what extent these enumerations are based upon actual examination and misinterpretation of anatomical facts it is impossible to say. In them the primitive elements of the body are air, bile, and phlegm, air having its seat below the navel, the bile between the navel and the heart, the phlegm above the heart. Seven organic products were believed to be formed from these primitive elements: watery chyle which in the liver and spleen forms blood, from which arises flesh which forms cellular tissue, from whence comes bone which generates marrow, which gives origin to semen and menstrual blood. The ancient Hindoos are said to have practised dissection, it being held lawful to pursue such investigations for scientific purposes, though under many limitations and restrictions; but the sculptures of the rock-cut temples of Elephanta and Ellora show ignorance of the anatomy of muscles. Later authors appear to have had a vague idea of the circulation of the blood, as they state that the watery chyle circulates through the vessels and irrigates the system as water does a field.

The Chinese have not, even at the present day, any exact anatomical knowledge. The tracing of their crude notions back to the mists of the past is of purely archeologic interest, and it is difficult to say whether the allegations of great antiquity made for some of their medical writings are based upon authentic facts. They considered the elements of the body to be air, water, "metal," and "wood"; the liver to be the seat of the intelligence, the seat of life to be in the middle of the breast. Arteries and veins were not separately distinguished, but some notion of a circulation or translation of the blood appears to have been advanced, as it is stated that it completes a course throughout the body five times in twenty-four hours.

The Japanese in matters of anatomy copied from the Chinese. Their older writings are curious mixtures of fact and error. They teach that the heart contains blood, rules all the other viscera, and is connected with the liver, lungs, spleen, and kidneys; that blood is prepared in three "combustion organs" of rather mythical character, perhaps the thoracic duct, the pancreas, and the lacteals. They assert the structure of the lungs to be like that of a honeycomb, and state that they contain a nourishing gas which penetrates the whole body outside the vessels that carry the blood. The brain, the spinal cord, and the marrow are said to be of one nature, the brain having the highest rank. The seat of the soul is stated by most authors to be the heart, as it has been seen in some animals to beat after the severing of the head from the body. Others place it in the brain, the spleen, the lungs, the kidneys, or the liver. The nerves are often confounded with the tendons, often described as tubular canals. In the middle of the eighteenth century, a physician named Yamawaki obtained permission from his prince to dissect a body, an illegal act that could be done only under powerful protection. He published his observations and declared that the older teaching should no longer be thoughtlessly followed. Dissection was thereafter surreptitiously practised, and very accurate wooden models of the skeleton were made. After this anatomical works from the Dutch were translated into Japanese.

It is among the Greeks that we first meet with a knowledge of anatomy that can be called scientific. With keen and active intelligence they examined and speculated upon all things in the world around them. Prepossessed with the anthropocentric theory of the universe, they attained only a partial and distorted view of natural phenomena, but often showed astonishing powers of generalization in speculative theories. Among them arose the group of so-called "natural philosophers," at the head of whom we find Pythagoras (584–504 B.C.). He attempted to explain natural phenomena by means of harmonic numbers which he considered as actual entities having mysterious powers, the elements of the body being comprised in the number 10, each single number $(1+2+3+4)$ having therein a counterpart. He was the first to deny the spontaneous generation of animals, holding that all life must spring from germs preexisting in the semen which, formed from the brain of the male, combines with moisture from the brain of the female, being the perfected foam of the blood. This idea is perhaps connected with that of the origin of the goddess of generation, Aphrodite (ἀφρός, foam), from the

foam of the sea. To the successors of Pythagoras are assigned by later writers some anatomical investigations and discoveries. Thus Empedocles (about 500 B.C.) discovered the labyrinth of the ear, Alcmæon, his contemporary, the Eustachian tube and the optic nerve, Diogenes of Apollonia (450 B.C.) described the great vessels, all after the dissection of animals. It is to him we owe the names of the amnion and the chorion, membranous envelopes of the fœtus. Empedocles is said to have advanced some crude ideas of the modern doctrine of the survival of fit and adapted animal forms. Democritus (about 450 B.C.) studied and compared the organs of man with those of lower animals and observed that they become adapted to certain purposes.

As in many primitive nations, the physicians of the Greeks became segregated into a guild. This was known as the Asclepiadæ, after the god Asclepias or Æsculapius, from whom they claimed descent. With the advance of culture, the need of a more careful investigation of the human body became evident, and about 430 B.C. a group of physicians of this guild arose who pursued a more rational method. The principal of these was the celebrated Hippocrates, often called the "father of medicine." A large body of writings formerly ascribed to him has been shown by modern research to be the product of his school rather than his individual work. The anatomical data found therein are evidently obtained mainly from the dissection of animals, although the osteology is that of man. The statements concerning the bones and sutures of the skull are fairly accurate, as are also those concerning the larger bones and joints. The heart (apparently described from that of man) is recognized as forcing the blood and pneuma or vital spirits of the air through the vessels, and the brain is in some writings distinguished as the organ of thought and conscious sensation. Tolerably accurate though these facts may be, the conceptions of the elementary constitution of the body were erroneous in the extreme, being similar to the speculations of the natural philosophers. It was believed that the bodies of living things were composed of four elements—earth, water, air, and fire—proper mixtures of which produced the so called elementary fluids blood, mucus, black and yellow bile; that yellow bile was formed in the liver, black bile in the spleen; that the different organs were produced by the action of "innate heat" upon the elemental fluids, the food stuffs, and the aqueous and earthy bases of the body. Muscles were not usually recognized as distinct from the general mass of the flesh. Arteries were not distinguished from veins, both being described under the common name of φλεβές. Under the term νεῦρα, nerves were likewise confounded with tendons or even sometimes with vessels. The brain is described in some passages as an organ for the absorption of superfluous mucus which it again gives out, and for the secretion of semen which is conveyed to the testes by the spinal cord. The lungs are said to take up cold air and pass it through tubes (ἀρτηρίη) to the heart for the purpose of cooling that organ. These characterizations show that the ideas then prevalent as to the structure of the body were largely imaginary, the necessity of controlling hypotheses by exact observation not yet being fully realized.

The conceptions of Plato as to the constitution of the body and its union with a mortal and an immortal essence were founded upon the Hippocratic anatomy. He imagined the seat of the immortal soul to be in the head, that of the higher passions in the upper thorax, and the heart to be "the centre or knot of the blood-vessels, the spring or fountain of the blood which is carried impetuously around"; and that it is cooled by the soft, spongy, and bloodless lungs. The lower passions he supposed to be placed in the thorax below the diaphragm, "in the same house" with the liver, which is "solid and smooth and bright and sweet, and also bitter, in order that the power of thought which originates in the mind may be reflected as in a mirror." The uterus he considered a wandering organ, that, like a wild beast, seeks satisfaction for its inordinate desires. Death he thought to be caused by the separation of the soul from the marrow, of which the brain is the most perfect part, and whose basis is "triangles"—a Pythagorean conception.

In these remarkable speculations we discern an attempt to ascertain by imagination alone, without any careful examination, the purpose or end for which structures are formed. This teleological error, the belief that the mind can discern the "final causes" of structure, tinctured all the anatomical investigations of the ancients.

Aristotle (384–323 B.C.), a pupil of Plato, opposed the idealism of his master, insisting that the proper method of advancing science is to first collect all the facts or particulars and afterward deduce from them causes and principles. His extraordinary industry and activity and his penetrating intelligence had a great influence not only upon his own time, but upon the scientific thought of all subsequent ages. He may be said to have originated the sciences of comparative anatomy and morphology, and was the first to conceive the animal kingdom as a connected genetic chain. By the aid of Alexander the Great he was able to collect vast stores of material, which he utilized as far as the limited resources of that age would permit. He dissected numerous animals and gave a fairly accurate idea of their constitution. A great deal of his classificatory work holds good to the present day. He distinguished arteries from veins by their structure, but grouped them together as φλεβές, correctly describing many of their principal branches. He considered, however, that some of the arteries carried only "pneuma." Certain of the nerves he distinguished from tendons, supposing them to be hollow tubes (πόροι), a name which he also applied to the ureters. Vessels and nerves he believed to arise from the heart, which he therefore considered as the seat of movement and of the soul. Different from the usual four elements is his principle of life, a fifth element (*quinta essentia* of after writers) which produces heat and cold. He appears to have considered this, however, as a function of the organized body. He seems to have been aware of the lacteals and to have supposed them to empty into the inferior vena cava and the aorta. His division of the body into structures and products composed of parts similar to each other and the whole which they compose (homœomeria) and of others formed of dissimilar parts is an adumbration of the modern conception of tissues and organs. In the domain of purely human anatomy he depends upon other authors, and expressly says "the internal parts of the human body are unknown or are supposed to be the same as the similar or analogous parts of animals." He studied the development of the chick in the egg, and held that it was an advance from a simple to a more complicated form. Observations of putrefying matter and of many cases in which germinal development is obscured led him to the view that animals may be generated spontaneously—"*Corruptio unius est generatio alterius.*" These views were destined to have a powerful influence upon subsequent speculation.

A contemporary of Aristotle, Praxagoras (about 335 B.C.), appears to have been the first clearly to distinguish arteries from veins both by structure and function. He held that arteries normally contain air during life, but when wounded, blood is drawn into them from the surrounding parts. The brain he supposed to be an appendage to the spinal cord.

Under the patronage of the Ptolemies the natural sciences flourished greatly in Egypt during the third century before Christ. At Alexandria the "Museum" was founded, an institution very like a modern university, provided with a large body of teachers and having students from the entire civilized world. Here dissection was publicly practised for the first time; the Egyptian custom of embalming the dead probably aiding to break down the prejudice against it. A large number of anatomical specimens were made and a vast library collected. The advances were considerable. Herophilus (335–280 B.C.), called by Fallopius "the evangelist of anatomists," especially investigated the brain, which he believed to be the organ of thought and motion. He

named the calamus scriptorius, surmising it to be the seat of the soul, discovered the sinuses of the dura mater, the confluence of the sinuses, which still bears his name (*torcular Herophili*), the retina, the uvea, and ciliary processes of the eye, the hyoid bone, the lacteals and lymphatics. He gave the duodenum its present designation (δωδεκαδάκτυλον = duodenum), distinguished the arteries from the veins, and admitted that both contained blood. It is said that he even vivisected criminals to obtain a knowledge of the soul.

His contemporary and rival, Erasistratus, was no less famous. He also saw the lacteals, and distinguished nerves of sensation from those of motion. He held that the vital spirits received from the air were changed to animal spirits in the brain, described well the heart and its valves, assumed a virtual connection between the arteries and the veins, holding that they discharge opposite each other. The arteries he supposed to carry air, blood being drawn into them when wounded. The substance of glandular organs he named the parenchyma (παρέγχυμα, poured in beside), holding that it is formed from altered blood effused from the blood-vessels. The name still remains. He held that the development of the fœtus is by epigenesis or new formation, instead of by preformation. He remarked the induration of the liver in dropsy, and may thus be said to have been the first to make observations in pathological anatomy.

The school of Alexandria gradually declined and made no further progress in anatomy, it even being held by certain of its teachers that a knowledge of that science was unnecessary for the healing art. The influence of the anatomical teaching of Herophilus and Erasistratus was, however, of wide extent.

Asclepiades (128–56 B.C.) revived the atomic theory of Leucippus, Democritus, and Epicurus, applying it to the structure of the body, which he conceived as composed of innumerable minute particles, the "leptomeres," cognizable by the understanding though not by the senses, between whose interstices the fluids of the body move. This appears to be the first hint of the modern cell theory.

The rise of the Roman empire transferred the centre of civic activity from the Eastern cities to Rome. Among the earlier Roman writers on medical subjects we find Celsus, who lived under Tiberius and Claudius (about 50 B.C. to 7 A.D.). Such of his works as have survived are interesting as showing the value placed upon anatomical studies at this period. He speaks decidedly as to dissection: "The examination of dead subjects is imperatively necessary for students, as they ought to know the position and order of the parts." Of osteology and the larger viscera he shows some accurate knowledge marred by numerous errors.

Marinus (under Nero) is known to us only through the writings of Galen, who praises his anatomical knowledge. He is said to have given excellent descriptions of the muscles and glands. He distinguished seven pairs of cranial nerves, apparently those mentioned by Galen, as follows: I. Optic; II. oculomotor and patheticus; III. ophthalmic branch of the trigeminus, IV. superior and inferior maxillary branches of the trigeminus; V. facial and auditory; VI. glosso pharyngeal, vagus, spinal accessory and sympathetic; VII hypoglossal (?).

Rufus of Ephesus (under Trajan) had considerable reputation as an anatomist. He discovered the Fallopian tube (in the sheep), the optic chiasm, and the capsule of the crystalline lens. He wrote a work intended for students' use, giving the names of parts of the body, but only fragments of this remain.

Soranus of Ephesus (under Trajan and Hadrian, some twenty years before Galen) described with considerable accuracy the internal genital organs of the female, and it seems clear that he must have dissected sufficiently to inspect them. He distinguished the vagina from the uterus, stated that the latter has the form of a cupping glass, and is connected with contiguous parts by means of membranes, so that it is impossible that it should be endowed with independent movement. His statements concerning the ovaries and oviducts are, however, obscure.

Far surpassing these, and indeed excelling all other writers of antiquity in anatomical exactitude, was Claudius Galen of Pergamus, a physician at Rome under the Antonines (A.D. 131–201). He studied at Alexandria, and esteemed himself especially fortunate in having there seen a complete human skeleton. He was an arduous investigator, dissecting many animals and even vivisecting some in order to ascertain the functions of nerves. He may indeed be said to have been the first physiological anatomist. Numerous errors of description make it certain that he never dissected the human body, but it is evident that he investigated that of the monkey, probably *Macacus ecaudatus* (Geoffr.) of the north coast of Africa. Many of his descriptions hold good to-day, and all are of such value that his authority in anatomy was dominant for more than thirteen hundred years. He was strongly prepossessed with teleological ideas, and assumed false physiological notions (usually derived from his predecessors) as a basis for the interpretation of structure. He was greatly impressed with the dignity and importance of his work, calling it "a religious hymn in honor of the Creator."

He held that the food undergoes "coction" in the stomach, from whence it passes to the liver, where, by the influence of "natural spirits," it is converted into blood which enters the vena cava, part of it proceeding peripherally to give alimentation to the limbs, part to the left side of the heart where the "innate heat" removes from it the part unsuitable for the nutrition of the more delicate organs of the body (smoke, fuliginous matter) which is expelled by the lungs. He supposed the greater part of the blood to be distributed by a to and fro oscillation in the veins throughout the body, while a portion passes through minute holes in the interventricular septum into the left ventricle, where it mingles with pneuma received from the lungs with the blood in the pulmonary veins forming "vital spirits" (Hippocrates); the mingled blood and vital spirits then pass into the aorta and the arteries, in which they oscillate to and fro, giving life to the body. He adopted the view of Erasistratus, that pore-like openings at the termination of the arteries communicate with the veins. He taught that there are, therefore, two kinds of blood: one, contained within the veins, suitable for nutrition and growth: the other, in the arteries, suitable for the maintenance of life. The blood that goes to the brain there undergoes a further change: by the choroid plexuses of the ventricles its vital spirits are further refined to "animal spirits" suitable for producing motion and activity (Erasistratus); the unused residue is expelled through the cribriform plate of the ethmoid bone; the animal spirits being distributed to various parts of the body by means of the tubular nerves (Aristotle). The brain he deemed an organ for the secretion of mucus and at the same time the seat of the soul, of which the natural spirits, the vital spirits, and the animal spirits are all modalities.

Notwithstanding these faulty assumptions, which greatly retarded the development of correct ideas concerning the actual functions of the body, the services that Galen rendered to anatomy were real and important. His descriptions are clear, exact, and, barring some errors derived from his preconceptions or the material he used, fairly accurate.

In osteology and arthrology he is at his best, and many of his designations of bones and joints are still in use. In the muscular system he described for the first time the muscles of the face, larynx, and tongue. The muscles of the limbs he separated nearly as is now done. He omitted the opponens pollicis (not found in apes), while in his description of the muscles of the foot he included some ape-like characters. His descriptions of the vascular system are marred by his preconceptions. He made the veins arise from the liver, the arteries from the heart, which he did not consider to be muscular although composed of fibres. He considered the spinal cord to be an appendage to the brain and developed from it, that nerves of sensation arise from the brain, those of motion from the spinal cord, and mixed nerves from the medulla ob-

longata. He noted that the sensory nerves are soft, the motor harder. The olfactory bulb and tract he correctly considered as an extension of the brain, and hence excluded it from his enumeration of the cranial nerves (Marinus?). He knew the ventricles of the brain, the fornix, the corpora quadrigemina, the terms nates and testes applied to the latter being his own. He was acquainted with the membranes of the brain, with the pleura, the pericardium, and the peritoneum. The divisions of the alimentary canal he accurately described. The genital organs of the male and female he considered essentially the same, the ovaries corresponding to the testes and secreting a seminal fluid that is conveyed to the uterus by the Fallopian tubes.

The decline of the Roman empire caused a gradual decay of intellectual culture and a total neglect of all sciences of investigation. It is only occasionally that we find in the writings of some compiler like Oribasius (A.D. 326–403) an indication of a new discovery. He is said to have been the first to describe the membrana tympani and the salivary glands. The cultivation of literature gradually declined and but few, even of the clergy, could read or write. Superstition and vague tradition usurped the place of science. No one thought it necessary to ascertain the structure of the human body when it was universally held that it was controlled by spiritual influences wholly independent of physical or natural laws. Anatomy was forgotten and the treatises of its founders either destroyed or suffered to remain in almost complete oblivion. Almost, not quite, for the torch of science, laid down by the rude hands of the West, was taken up and relighted by the scholars of the East.

The Arabians now began to take an active part in intellectual culture. In imitation of the school of Alexandria they founded great universities at Bagdad, Bassorah, Damascus, Alexandria, Cordova, and Granada. Forbidden by the Koran to dissect the human body, or even to make any representation of it, the physicians of these schools had recourse to Greek authors, particularly to Hippocrates, Aristotle, and Galen. On these they made long commentaries, their remarks often showing perspicacity and judgment. The most important authors of the Arabian school who treated of anatomy are Rhazes (Abu-Bekr-Al-Razi, 850–923 A.D.), Ali Abbas (Ali ben el-Abbas, Haly Abbas, 930–994), and Avicenna (Abu-Ali-Ibn Sina, 980–1037). Their direct contributions to anatomy were not great, but their nomenclature was for a time adopted by European writers. A translation of Ali Abbas' work into Latin, by Constantinus Afer, a Benedictine monk (*circa* 1080), is probably the first work on anatomy in that language (Hyrtl).

The leavening influence of the crusades now began to be felt. The uniting of the scattered peoples of Western Europe into vast armies that made long journeys by land and sea, and came in contact with nations of totally different culture and habits of thought, had great effect in combining the small, warring, feudal factions into larger social units more susceptible of advancement, in opening new avenues of commerce, in diffusing a knowledge of the learning of the East, and in bringing about a revival of intellectual activity. New universities were founded throughout Europe; at Bologna in 1116, at Padua in 1228, at Salamanca in 1239, at the Sorbonne in 1253. Others whose foundations dated back to the Roman period received new accessions. Among the latter were Salerno and Montpellier, at each of which an active medical school was established. At Salerno was seen the first symptom of a revival of practical anatomy, for it is said that the Emperor Frederick II. (1194–1250) made a law that no one should practise surgery without having been previously examined in anatomy, and provided that a dissection of the human body should be made at Salerno once every five years, inviting physicians and surgeons from all parts of the empire to witness it. It has been erroneously stated that the bull of Pope Boniface, *de sepulturis*, issued in 1300, was an interdict against dissection; but it was really intended to prevent the practice of dismembering and boiling dead crusaders for the purpose of more easily transporting their bones to their native land. The Senate of Venice, in 1308, decreed that a human body should be dissected annually. It is uncertain to what extent these dissections were carried, but it is probable that only the larger viscera were examined.

Among the products of the school of Salerno that have survived are the "Anatome Porci" of Copho, and the anonymous "Demonstratio Anatomica." These are both based wholly upon dissection of animals.

There is evidence that at this period autopsies were occasionally held to determine the cause of death, whether by poisoning or otherwise. It is also said that the bodies of those who had been hanged were, in Italy, not infrequently given over to physicians for dissection. Occasionally bodies were stolen for anatomical purposes.

It is at about this time that occurred the first attempts at pictorial representations of bodily structure. These are found in a translation of Galen made by Nicholas Regio and published at Dresden in the fourteenth century. Two manuscripts on anatomy by Mondeville and Magister Ricardus that have survived from the school of Montpellier also contain crude drawings of structures.

The credit of first establishing systematic public demonstrations of anatomy belongs undoubtedly to Mundinus (Raimondo da Luzzi, Mondino, 1276–1236), who taught at Bologna. Not content with expounding Galen, Abbas, and Avicenna, he brought the science back to the correct path of ocular investigation. At least three bodies of women were publicly dissected by him, and there is reason to believe that the number was considerably greater. He is the author of a small work known as the "Anathomia Mundini," that was circulated extensively in manuscript before the invention of printing, and afterward ran through at least twenty-three editions. Although very incomplete and containing numerous errors, it was used as a text-book for two hundred years. It is very difficult to read, as much of the nomenclature is borrowed directly from Arabian authors. The abdomen appears as the "myrach," the peritoneum the "cyphach," the omentum the "zirbus," the sternum "the shield of the mouth of the stomach." Some of his appellations are still used, as "nucha" for the nape of the neck, "saphena" for the great superficial vein of the thigh. His anatomy is crude and incomplete rather than positively erroneous. He held that the body has three cavities (ventres): the head, containing animal members; the thorax, spiritual members; the abdomen, natural members. His anatomy of the heart is fairly accurate, and he nearly discovered the lesser circulation, as he says that blood is carried from the heart to the lungs by the pulmonary artery.

In view of the imperfect and incomplete character of this treatise of Mundinus, it is difficult to understand its great influence upon the anatomical instruction of that age. It was, however, the first work since Galen avowedly based upon personal inspection of the human body, and it appealed to the mediæval spirit of curiosity that now began to manifest itself. The same impulses that led Marco Polo to the territories of the Great Khan and impelled the alchemists to new discoveries in their search for the transmutation of metals, animated many physicians of that time in their examination of the body of man. A zeal for anatomical studies arose, first in the Italian, afterward in the French and German universities. At Mundinus' own university of Bologna definite rules for dissection were established. At Montpellier the medical faculty obtained from the Duke of Anjou a regular license to dissect the cadavers of criminals, which was successively continued by the kings of France (Charles VI., 1396; Charles VIII., 1496). In Prague dissection was practised from the very foundation of the university in 1348, and a building was given for that special purpose in 1460. At Vienna dissection was practised as early as 1404, and made a definite part of the medical curriculum in 1433. Pope Sixtus IV. granted special authority for dissections at Tübingen in 1482. The first anatomy act was passed in 1540, allowing the company of barbers and surgeons of London four bodies annually for dissection.

Yet this was nowhere carried on with the care and precision that characterize work in modern schools. The freeing of muscles, vessels, and nerves from the tissues that envelop them seems not to have been understood. Usually the great cavities of the body were opened and the principal viscera therein contained were displayed and demonstrated. Slices were removed from the cadaver by a razor in the hands of an attendant. The modern methods of injection and preservation were, of course, unknown; and a cadaver was soon a mass of disgusting and noxious putrescence. There was as yet no approach to exact and complete anatomical investigation.

That anatomy was but of slight assistance to either medicine or surgery is amply shown by the records of the time. Indeed, it fell into such disrepute that Paracelsus (Theophrastus Bombastus von Hohenheim, 1493–1541) declared it to be useless to know the internal structure of the body, that a knowledge of the shape or situation of the lungs, heart, or stomach was of no value in the diagnosis or treatment of disease. In 1525 he burned the works of Galen and Avicenna before his pupils at Basle, denouncing these teachers as blind guides. Some of the doctrines of Paracelsus reappear at later periods. He considered the body to be a microcosm representing the entire external universe, formed from pre-existing and indestructible germs (Weismann's germ plasm), and governed by astrological influences, the sun affecting the heart, the moon the brain, Mercury the liver, etc., etc. The functions of the body he supposed to be carried on by the *archæus*, a sort of *deus in machina*, that resided in the belly.

Among those who carried on the work started by Mundinus and somewhat extended the domain of anatomy are:

Gabriele de Zerbi (1468–1505), professor at Padua, Bologna, and Rome, who first separated the organs into systems, described the musculature of the stomach, and the puncta lachrymalia. He knew that the tunica vaginalis testis is derived from the peritoneum.

Achillinus (Alessandro Achillini, 1463–1512), professor at Bologna and Padua, author of a commentary on Mundinus, who discovered the malleus and the incus, the labyrinth of the ear, the patheticus nerve, the ileo-cæcal valve, and the entrance of the bile duct into the duodenum.

Alessandro Benedetti (1460–1525), professor at Padua in 1490, afterward at Venice, who built the first anatomical amphitheatre. His demonstrations were public and he complains of the "numerous populace" that crowded to them. He wrote a work on anatomy that is one of the very best of the period.

Berengarius Carpensis (Jacopo Berengario Carpi, 1470–1530), professor at Pavia and Bologna, author of a commentary on Mundinus. He showed the mythical character of the *rete mirabile* which Galen had described as existing on the internal carotid arteries (as in the herbivora), and was the first to deny that orifices existed in the interventricular septum. He stated that he had dissected more than a hundred cadavers, but does not say that these were all human.

Marcus Antonius (Marc Antonio della Torre, 1481–1512), professor at Padua and Pavia, the pupil of Lionardo da Vinci who is said to have designed plates for his work. Lionardo was himself an anatomist fully equal to any of the pre-Vesalian epoch. He made many dissections and carefully reproduced them in drawings that show a great deal of anatomical knowledge. He seems to have come nearer to the circulation of the blood than any of his contemporaries. "The heart," he says, "is a muscle of great strength, much stronger than the other muscles. The blood that returns when the heart opens again is not the same as that which closes the valves." It should be remembered that both Raphael and Michael Angelo studied anatomy and left anatomical drawings. Concerning Michael Angelo, the slanderous story was circulated that he had practised vivisection on a criminal in order to get the expression that he desired to portray in a picture of the crucifixion.

Vidus Vidius (Guido Guidi, 1545–1569), physician to Francis I., and professor at Paris and Pisa, whose name is retained in the Vidian canal and the Vidian nerve; Guintherus Andernacensis (Günther von Andernach, 1487–1574), professor at Louvain and Paris; and Jacobus Sylvius (Jacques Dubois, 1478–1555), professor at Paris, are all chiefly famous as being the instructors of Vesalius. Günther had both Vesalius and Servetus as prosectors in his laboratory at the same time. His description of the valves of the heart is good, and he appears to have been the first to discover that both air and blood undergo changes in passing through the lungs. Sylvius greatly improved nomenclature, assigning designations to muscles and vessels, distinguishing voluntary from involuntary muscles, and demonstrating more by personal dissection than was done in other schools. He discovered valves in some of the veins, but appears to have had no idea of their function.

The time was now ripe for a new advance. The invention of printing and consequent general diffusion of ancient literature, the discovery of new countries and continents, the progress of invention and the flourishing condition of pictorial and plastic art, created an intellectual activity that would no longer brook the restraints of schools and the unsupported dicta of the ancients. The power of tradition, which had weighed like an incubus upon anatomical teaching for over thirteen hundred years, was now to be rudely shaken. There arose a group of anatomists who were to pursue their work again in the proper spirit of free inquiry and to institute for the first time in the history of the science a careful examination of the human body made with thoroughness and skill. The chief of these was Andrew Wesel, more commonly known by his Latin appellative of Andreas Vesalius, who was born at Brussels, December 31, 1514. He was the son, grandson, and great-grandson of distinguished physicians, a fact of which he was justly proud. He showed a taste for anatomical investigations at an early age, and after an excellent training in Latin, Greek, and perhaps in Arabic, at the university of Louvain, he went to Paris to work in the laboratory conducted by Vidius and afterward by Sylvius at the school founded in 1530 by Francis I. His description of the way in which anatomy was pursued there shows the state of teaching at that time. The demonstrations were mostly upon animals, and upon those rare occasions when the human body was examined it was hurried over in three lessons, the teacher merely opening the great cavities and so hastening over the demonstration that "more anatomy might be learned in the shop of a butcher than in such a dissecting room." Except the eight muscles of the abdomen which were badly mangled and improperly prepared, not a muscle was demonstrated, nor were any bones shown, much less were nerves, veins, and arteries properly dissected and displayed.

At odd times Vesalius haunted the city cemeteries to procure chance bones turned up by the spade of the sexton. He early noted errors in the descriptions of Galen and Mundinus. Returning to Louvain he conducted anatomical demonstrations there, and possessed himself, it is said, of an entire human skeleton by remaining all night beyond the city gates and robbing the gibbet of a body partially destroyed by birds. He afterward went to Italy, and received, in 1537, at twenty-three years of age, the appointment of professor of anatomy at Padua, already famous for its anatomical instruction. Here he at once achieved a striking success. His demonstrations were crowded; the clergy, the laity, even women thronging to hear him. He remained in Italy seven years, delivering courses in Pisa and Bologna as well as at Padua, a proceeding rendered possible by the short duration of each course, viz., seven weeks. While not employed in teaching he gave his time to the composition of his great work, "De Humani Corporis Fabrica, Libri VII.," the first attempt at a complete exposition of the structure of the human body.

In this we find the result of his own personal researches, a careful and generally accurate description of the anatom-

ical features of man made for the first time from actual inspection. As Vesalius himself says, it is an attempt to demonstrate the structure of man upon man himself. Galen's many errors, caused by his almost exclusive study of inferior animals, were unsparingly noted. Excellent plates made from drawings of preparations illustrated the work. These were so good that they were often ascribed to Titian, but they were probably the work of Stephen von Calcar, one of Titian's pupils, with perhaps some aid and advice from the master and an occasional drawing from Vesalius himself, who was skilful with the pencil.

From this epoch-making work modern anatomy may be said to have its birth. It is, however, by no means free from errors, both those due to hasty preparation, and those arising from the preconceptions then current. Vesalius still supposed that mucus passed through the holes in the cribriform plate, that the tubular nerves distributed animal spirits, etc. Many of his errors were pointed out by his contemporaries.

This new departure should be considered as belonging to the movement of the age. As has been already noted, the world was becoming impatient of traditionary authority and seeking for facts by personal observation and research. Vesalius' great work appeared in 1543, in the same year that Copernicus published his treatise "On the Motions of the Heavenly Bodies"; it was in 1521 that Luther made his memorable appeal before the Diet of Worms, and in 1534 that he completed his translation of the Bible.

The adherents of ancient tradition did not yield without a struggle. Vesalius was denounced by many, his former teacher Sylvius calling him an impious madman whose breath poisoned Europe. The errors of Galen which Vesalius had pointed out were explained in the most grotesque manner, either by supposing a corruption of Galen's text, or by the hypothesis that the human body had changed since Galen's time. The seven pieces of the sternum which Galen had described (from apes) were supposed to indicate how much larger and more developed the thorax was in Galen's time; the curvature of the thigh bones, not seen in modern man, was said to be their natural free condition before they were straightened by the wearing of tight breeches. More important were criticisms directed toward Vesalius' own demonstrations by Eustachius, who pointed out a number of errors, and thoroughly disapproved of the conduct of Sylvius. Vesalius seems to have taken this opposition very much to heart. He had previously resigned his chair, and now he went to Madrid, where, in the gloomy court of Philip II., he found a most uncongenial atmosphere. He was surrounded by enemies who attempted to stop his work by the power of the Inquisition. Philip asked from the University of Salamanca an opinion as to the permissibility of dissection, and the reply of the learned doctors was that since it is useful to man it may be allowed (1556). Restless and ill at ease, Vesalius wished to return to his chair in Italy, now vacant by the death of Fallopius. He was destined never to do this. Making a voyage to Palestine in the fulfilment of some vow,* recalled while there by the Senate of Venice to resume his chair, he was shipwrecked on the island of Zante, and suffered so much from exposure that he died there, October 15, 1564. He was one of the great pioneers and pathmakers of science, worthy to rank with Copernicus and Columbus. Anatomy has never lost the impulsion due to his arduous efforts. He found it a mass of crude speculations based on ancient authority, he left it a recognized science having for its basis actual observation of structure.

Vesalius was by no means alone. Two other great figures stand out at this epoch, Eustachius (Bartolommeo Eustacchi, 1520–1574), professor of anatomy at Rome, and Fallopius (Gabriele Fallopio, 1523–1562), professor at Ferrara, Pisa, and Padua. It is to Eustachius that we owe the first idea of investigating the tissues, also the conception that to understand adult structures we should examine the fetal ones. To correct the current errors in Vesalius and others, he prepared a great illustrated work on the controversies of anatomists, but it was never published, and the plates that he had made for it at great expense were long supposed to be lost, but were finally discovered in the Vatican library and presented by Pope Clement XI. to Lancisi, who published them in 1714. They were the first copper plates used for anatomical illustrations, and show that their author had anticipated many of the discoveries of his successors. The Gasserian ganglion and the pancreatic duct are clearly shown, and the ciliary muscle not only figured but given its modern designation. The name of Eustachius is preserved in the Eustachian tube, said to have been first discovered by Alcmæon, and the Eustachian valve of the fetal heart. He first described the membranous cochlea and the tensor tympani muscle, the origin of the optic nerve, the abducens nerve, the suprarenal capsules, and the ventricles of the larynx.

Fallopius was especially renowned for his exact description of the organs of hearing. He discovered the aqueductus and hiatus Fallopii, the communication of the mastoid cells with the middle ear, the stapes (also claimed by Eustachius), the fenestra ovalis, the chorda tympani, the aqueductus vestibuli, and the lamina spiralis. He gave the membrana tympani its present name and named the Fallopian tubes (previously discovered by Herophilus) the tubæ seminales. Poupart's ligament was first described by him, as also the hymen, the clitoris, the seminal vesicles, and the uriniferous tubules. He also described the ileo-cæcal valve, which was, however, probably known to Achillinus. He discussed the development of bones and teeth, and knew the ganglia of the spinal nerves.

In their zeal for knowledge the anatomists of that age are reputed to have not infrequently overstepped the bounds of common humanity. Vesalius, following the example of Herophilus, is said to have vivisected criminals, and the records found in the criminal archives o[illegible] Florence (1545–1570) show beyond dispute that it was b[illegible] no means uncommon to send living persons to Pisa "t[illegible] be made an anatomy." While this language seems to in[illegible] dicate that such subjects were dissected alive, there i[illegible] on the other hand, some evidence to show that they we[illegible] first executed by smothering or otherwise.

Many other almost equally famous men contribut[illegible] to the anatomical knowledge of the period. Amo[illegible] these are the following:

Servetus (Miguel Serveto, 1509–1553), a Spaniard fr[illegible] Villanova, in Arragon, burned at the stake by Calvin, [illegible] Geneva, for heretical opinions. He was the first clearly [illegible] describe the pulmonary circulation and the change fr[illegible] venous to arterial blood that occurs in the lung. T[illegible]hi[illegible] description occurs in the rare work "Christianismi Re[illegible]sti[illegible]tutio," published by him at Vienne in 1553. In this [illegible] h[illegible] clearly states that air mixed with blood passes from the lungs to the heart. "*A pulmonibus ad cor non sim*[illegible]*ae*[illegible] *aer sed mixtus sanguine mittitur ad arteriam venosa*[illegible]*n.*" He had, however, no idea of the greater or general cir-culation.

Columbus (Matteo Realdo Colombo, 1494–1559), the warm friend of Vesalius, and who immediately succe[illegible]ded him at Padua and afterward taught at Pisa and R[illegible]me. He dissected with great assiduity, completing at [illegible]east fourteen bodies in a year. He also ransacked old [illegible]har-nel houses for bones and compared about half a [illegible]mil-lion of skulls. He was an ardent investigator, de[illegible]on-strated experimentally the lesser circulation, prob[illegible]ably without any knowledge of the prior work of Serv[illegible]tus, and had an accurate idea of the functions of the v[illegible]lves of the heart.

Ingrassias (Giovanni Filipo Ingrassia, 1510–1580), [illegible]pro-fessor at Naples, of high rank as an osteologist, [illegible]ho studied the sphenoid and ethmoid bones.

* The report that he was condemned to death by the Inquisition for opening by accident the body of a living man, and that his sentence was by Philip commuted to a pilgrimage, appears to be wholly without foundation, unsupported by the records of the Inquisition or of the royal archives.

Cananus (Giambattista Canano, 1515–1579), one of the earliest to mention the valves of the veins (1547).

Cæsalpinus (Andreas Cæsalpini, 1517–1603), the first to use the term *circulatio* in speaking of the movement of the blood. He had no clear and definite ideas on the subject, believing that the movement was oscillatory.

Arantius (Giulio Cesare Aranzio, 1530–1589), professor at Bologna, who discovered the ductus arteriosus, the corpora Arantii, named the hippocampus major, carefully described the gravid uterus, which he considered a muscular organ, and first spoke of a separation of the maternal and fetal blood.

Coiterus (Volcher Koyter, 1534–1600), of Gröningen, who investigated the osteology of the fœtus and the development of the bones.

Varolius (Constanzo Varolio, 1543–1575), professor at Rome, who made special researches into the brain and nervous system, describing the base of the brain and the apparent origin of the cranial nerves. His name is preserved in the pons Varolii.

Bauhinus (Caspar Bauhin, 1560–1624), professor at Basle, who made improvements in terminology. (The discovery of the ileo-cæcal valve, ascribed to him, is due to Fallopius.)

Spigelius (Adrian van den Spieghel, 1578–1625), of Brussels, who made a special study of the liver, one of whose lobes still bears his name.

Fabricius ab Aquapendente (Girolamo Fabrizio, 1537–1619, so called to distinguish him from Fabricius Hildanus, a celebrated surgeon of the period), who was the successor of Fallopius at Padua, and worthily maintained the reputation of that celebrated school. He erected at his own expense an anatomical amphitheatre which still remains. It is a small dark pit with seats rising almost perpendicularly about it, excluding the light so that all dissections must have been by candle light! It was here that Harvey learned anatomy and obtained from Fabricius the germs of the knowledge which was to result in the discovery of the circulation of the blood. Fabricius was the first to demonstrate in a complete manner the valves of the veins. The first mention of these is by Stephanus (Charles Étienne) of Paris in 1845, who refers to them as "apophyses membranarum," intended to prevent the regurgitation of the blood. Sylvius (1555) noted them in several veins, Eustachius in the coronary vein (1563). Vesalius seems not to have realized their importance, but figures them in the hepatic veins. Fabricius, however, wrote a complete treatise upon them ("De Venarum Ostiolis," 1603), and states that they prevent the overdistention of vessels when blood passes from the larger to the smaller veins. He also studied the development of the human fœtus and of the embryo chick, the muscular coat of the bladder, the œsophagus, stomach, and intestines, particularly the appendix vermiformis. He was succeeded at Padua by Casserius (Giulio Casserio, 1561–1616), who paid especial attention to the organs of voice and hearing and discovered the stapedius muscle. The musculo-cutaneous nerve of the arm is sometimes called the nervus perforans Casserii.

The zeal for investigation instituted by Vesalius and carried on by his contemporaries and immediate successors was undoubtedly a great advance over the ignorant apathy that preceded it, but it was not so much a new movement as a revival of an old one. The anatomy of that time was, after all, the anatomy of the Greeks, carried to a greater degree of detail, it is true, but marred by the same teleological errors. The spiritualistic theories of Hippocrates, Aristotle, and Galen still prevailed and blinded the eyes of anatomists to the true significance of structure. The doctrine of the tissues, hinted at by Aristotle, and dimly groped after by Eustachius and Fallopius, had borne as yet no fruit. The development of the embryo had been but little studied and its details were imperfectly known. In osteology and arthrology the advances were greatest, the general features of the bones, joints, and ligaments being well described; but their nomenclature was as yet undeveloped, they being designated in each region by numbers. In the vascular system the veins were considered the most important vessels, it being supposed that the blood in them had an oscillatory movement which the valves modified without absolutely controlling its direction. The heart had been fairly well described, but as no one had shown experimentally the impossibility of regurgitation of blood into it from the aorta and the pulmonary artery, it was still supposed to be a sort of mixing reservoir for the blood and animal spirits. The permeability of the interventricular septum was still in dispute, it being held necessary for the mixing of the blood. The powerful muscular character of the heart was still unrecognized, and though the lesser or pulmonary circulation had been mentioned by Servetus and Columbus, it was not generally accepted. The lymphatics, although seen and vaguely mentioned by several ancient authors, were not understood.

The macroscopic anatomy of the brain was not yet well known; the ventricles were supposed to be the reservoirs of the vital spirits, and the nerves to be tubular in character. The distribution of the cranial nerves was not clearly made out.

In splanchnology vague ideas prevailed. The liver and spleen were thought to be potent organs for the elaboration of blood, which was made in them as fast as it was distributed by the heart through the veins and arteries to be poured out into the substance of the organs. The pancreas, although discovered by Galen, was overlooked, as it is evident that Vesalius mistook for that organ the collective mesenteric glands. The ovaries were believed to produce a female semen.

Anatomical instruction was still carried on mainly by demonstrations by the professor. The prosectors usually made dissections in sight of the pupils, the professor sitting opposite and with a little wand pointing out the part described. The muscles were dissected in one day, the contents of the head, chest, and abdomen in a second, the bones and ligaments in a third. It was not usually practicable to extend this time on account of the rapid decay of the body. As, however, the whole day was occupied by each demonstration, the work was not as superficial as might at first appear.

Another great advance was now made in a domain which, although physiological in its scope, yet reacted powerfully upon anatomy by affecting conceptions of bodily structure. This was the careful inductive demonstration (commonly called discovery) of the circulation of the blood made by the renowned William Harvey who was born April 1, 1578. He studied at Cambridge and Padua, graduating from both universities in 1602. In Italy he became acquainted with the views of Fabricius whose pupil he was, as to the wide distribution of the valves of the veins, and those of Columbus regarding the pulmonary circulation. It was not, however, until he had made many vivisections and studied the movements of the heart in many living animals, under varying conditions, that he attained to a correct idea of the double circuit made by the blood.

Harvey began to teach the new doctrine in his lectures at the Royal College of Physicians as early as 1615, but did not publish them until 1628, when appeared, at Frankfort, his "Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus" (An anatomical treatise on the movements of the heart and the blood in animals). In this he frankly breaks with traditional teaching: "I profess to learn and teach anatomy not from books, but from dissections; not from the suppositions of philosophers, but from the fabric of nature." * Showing that the anatomical arrangement of the valves of the veins and of the heart necessarily implies a movement of the blood from the veins toward the heart and from the heart into the arteries, he demonstrated such movement by a compression of veins and arteries and by various other experiments in living animals, making an earnest plea for

* In the possession of the Royal College of Physicians of London are preparations of the blood-vessels, mounted on boards and showing the aortic valves, that are said to have been prepared by Harvey when a student in Italy and used for demonstration to his classes. Hyrtl believes them to be the oldest anatomical preparations extant.

comparative anatomy: "Had anatomists only been as conversant with the dissection of the lower animals as they are with that of the human body, the matters that have hitherto kept them in a perplexity of doubt would, in my opinion, have met them freed from every kind of difficulty." For the first time we see doubt cast upon the doctrine of "spirits." Says Harvey: "We are too much in the habit of worshipping names to the neglect of things. The word blood has nothing of grandiloquence about it, for it signifies a substance which we have before our eyes and can touch; but before such titles as spirit and innate heat we stand agape."

The new doctrine was at first universally rejected, especially in Italy where most of the preliminary discoveries had been made that led to Harvey's conclusions. As in the case of Vesalius, the innovator was greeted with abuse and detraction instead of demonstration and legitimate argument. Harvey received this, however, with a singularly calm and judicial spirit. He says: "To return evil speaking with evil speaking I hold to be unworthy in a philosopher and searcher after truth. I believe that I shall do better and more advisedly if I meet so many indications of ill-breeding with the light of faithful and conclusive observation." The only opponent he deigned to answer was Jean Riolan (Riolanus, Jr., 1577–1657), professor at Paris, so renowned for his acerbity in controversy that it was said of him that he would rather give up a friend than yield an opinion. Harvey's reply was judicial and complete, but failed to convince Riolan, who obtained a decree from the Faculty at Paris forbidding the teaching of the new doctrine, and opposed it up to the time of his death. Harvey lived to see his views almost universally accepted, dying in 1657, a few years before Malpighi discovered the capillaries and thus placed the anatomical basis of the circulation beyond cavil (1661).

Harvey's work called more attention to the heart, and many points in its gross anatomy were now established. Among those who worked to this end may be mentioned Richard Lower of London (1631–1691, tuberculum Loweri), Raymond Vieussens (1641–1718, fossa ovalis), professor at Montpellier, Nils Stensen (Nicholas Stenonis, 1638–1686), professor at Copenhagen, who worked at the musculature and looped fibres, and Adam Christian Thebesius (1686–1732), who discovered the foramina Thebesii.

As a consequence of the doctrine of the circulation, the distribution of blood-vessels was more accurately studied. A passage in Sylvius is sometimes cited to show that he suggested injections, but it is clear that he could not have made any effective use of them. The first to do this was Stephen Blancaard, of Middleburg, Holland (1650–1702), who, in 1675, succeeded in injecting the blood-vessels. Others obtained great success with this method, especially Frederick Ruysch (1638–1731), professor at Amsterdam, whose preparations were justly famous. It is to him we owe the demonstration of the vascular distribution in the choroid of the eye (tunica Ruyschiana = chorio-capillaris). Using fine injections he found vessels in every part of the body in such numbers that he inclined to the belief that the body was mainly composed of them, "*totum corpus ex vasculis*."

Closely associated with the anatomy of the blood-vascular system is that of the lymphatics. These structures were probably seen in goats by Aristotle and Herophilus, but as their course and termination were not determined, the remarks of those authors concerning them were overlooked or misunderstood. Eustachius saw and described the thoracic duct in the horse, supposing it to be a vein for the nourishment of the thorax. The chyliferous lymphatics were first observed in 1622 by Gaspare Aselli (1581–1626), professor at Pavia, in the mesentery of a dog lately fed. Misled by the prevalent conceptions as to blood formation, he thought they could be traced to the liver. His discovery was not published until 1627, and the next year such vessels were demonstrated in the mesentery of a criminal two hours after death by Fabrice de Peiresc, a senator of Aix, to whom Gassendi had communicated Asellius' discovery. In 1647, Jean Pecquet (1622–1674), a student at Montpellier, accidentally discovered the thoracic duct in a dog and traced it through the diaphragm to the receptaculum chyli (reservoir of Pecquet). It was still considered a vein, though further research showed its connection with the mesenteric glands. The distinction between the lymphatics and the mesenteric veins was first made by Nathanael Highmore (1613–1684), of Shaftesbury. Jan Van Horne (1621–1670), professor at Leyden, was the first to observe the thoracic duct in man, though Olaus Rudbeck (1630–1702), professor at Upsala, noted it about the same time. The latter also discovered the general lymphatics, distinguishing them as vasa serosa in 1651, their present name being given by Thomas Bartholin (1616–1680), professor at Copenhagen, who greatly extended the knowledge of them. Finally Anton Nuck (1650–1692), professor at Leyden, invented the method of injecting these vessels with mercury and traced them to nearly all parts of the body.

It was at about this period that anatomical science obtained great assistance by the invention of the microscope. As an instrument of research the simple microscope was not used until the seventeenth century, although the magnifying power of lenses seems to have been known in remote antiquity. The greater power of the compound microscope invented about 1590 by Hans and Zacharias Janssen, of Middelburg, Holland, still further stimulated investigation and led to the discoveries of Malpighi, Leeuwenhoek, Redi and others. The imperfection of the instrument so greatly affected its utility that many anatomists distrusted the results obtained from its use. After many attempts and partial successes by others, Chevalier of Paris (1824) and Amici of Modena (1827) finally succeeded in correcting chromatic and spherical aberration, thus producing an instrument by which minute structure can be accurately investigated.

The immediate result of microscopical investigation was, on the one hand, greatly to extend the knowledge of structure, and, on the other, to introduce novel ideas regarding generation and the diffusion of animal life. Marcello Malpighi (1628–1694), professor at Bologna, Pisa, and Messina, a man of great scientific force, laid the foundations of modern botany, of histological anatomy, and of embryology. His discovery of the capillaries in the lung of the frog has already been mentioned. Molyneux (1683) and Leeuwenhoek (1688) almost immediately extended this by finding them in the extremities of lizards and tadpoles. Malpighi discovered the red corpuscles of the blood in 1665. He published the first accurate account of the consecutive development of the chick, carrying his investigations as far as the imperfect instruments and methods of his time would permit. He greatly advanced the knowledge of glands, showing the structure of acini and ducts, demonstrated the glomeruli of the kidney and the splenic corpuscles which still bear his name, and by inflating the air vesicles showed the glandular structure of the lungs and the impossibility of air passing into the vessels by mechanical means. Misled by his imperfect instruments and crude methods of preparation he endeavored to show that the brain also has a glandular character. Having cooked the organ he thought that the gray matter appeared on examination to be composed of minute spherules connected with the fibrous central portion. He assumed that these spherules secreted the nervous fluid which was distributed by the nerves. This accorded with the prevalent ideas and greatly retarded a true appreciation of the structure of the brain.

Many other anatomists added to our knowledge of glands: Francis Glisson (1597–1677), professor at Cambridge, gave a description of the liver that is the basis of our knowledge at the present day; Johann Georg Wirsung, professor at Padua in 1642, discovered in man the pancreatic duct, previously found in the fowl by his pupil Moritz Hofmann (1621–1698), afterward professor at Altorf, a discovery that retarded rather than advanced anatomical science, for the pancreas was supposed to be a lymphatic gland and the duct a lymphatic leading from the intestine to the liver, and thus confirmed erroneous views of lymphatic distribution; Thomas Wharton (1610–

f London, wrote of the nature and classification ds, and discovered the duct of the submaxillary ıat bears his name.
aris a remarkable advance was made by the es- ıent by Jean Riolan, Jr., of the Jardin du Roi, rd the Jardin des Plantes, which was, in effect, a al laboratory where various problems of human ıparative anatomy could be studied. Jean Gui- Duverney (1648–1730) was an able demonstrator › popular that noblemen flocked to hear him. He ed the vulvo-vaginal glands (in the cow), to which Bartholin's name was afterward attached. He firmed the existence of the bulbo-urethral glands, covered by Méry (1645–1722) and named after the anatomist Cowper.
s Littré (1658–1725) described the urethral glands ır his name, and Martin Naboth (1675–1721) the of the neck of the uterus and the closed follicles same region. Lorenzo Bellini (1643–1704), pro- ıt Pisa, examined more carefully the structure of ney (uriniferous tubules). Thomas Bartholin 380), professor at Copenhagen, one of the most ıished anatomists of the seventeenth century, dis- the duct of the sublingual gland which joins n's duct, while the ducts of that gland that open ly into the mouth were found by August Quirin ınn (Rivinus, 1652–1753), professor at Leipsic. ct of the parotid gland, seen and described as a t by Casserius, was first recognized as a duct ter Needham, of London, in 1655. Nils Sten- :holas Stenonis, 1636–1686), professor at Copen- mentioned it in his inaugural thesis in 1658, and very is often assigned to him. Stensen was one most able thinkers of his time. He held that in › understand the function of organs we must termine their structure, and that no accurate dge of the brain can be had until we understand ucting tracts. He declared, contrary to the pre- opinion, that petrifactions are not mere erratic f nature, but the remains of plants and animals merly lived. The glands of the intestinal tract vestigated by Johann Conrad Brunner (1653–1727) ıann Conrad Peyer (1653–1712); those of the eye- Heinrich Meibom (1638–1700), professor at Helm- vhile Conrad Victor Schneider (1614–1680), pro- t Wittenburg, demonstrated the true nature of the ıembrane of the nasal fossæ, and thus overthrew ent doctrine of the secretion of mucus (pituita) brain and of the cerebral origin of catarrhal dis- Antonio Pacchioni (1665–1726), professor at liscovered the bodies that bear his name, situated e superior longitudinal sinus; and the synovial and so-called synovial glands were described by ı Havers (1692).
ythagorean and Galenical doctrine that the em- formed from two kinds of semen, generated re- ly by the male and female, was generally held. , following in the footsteps of his master Fabricius, ated the course of development not only in fowls mammals, and published (1651) a treatise on de- ent in which he formulated the famous proposi- t the egg is the primary stage of development for ıals. The original phrase is, "*Ovum esse primor- mmune omnibus animalibus*," afterward currently ated as, "*Omne vivum ex ovo.*" According to this ıe ovum is the essential element in the genera- ocess. This belief was shaken by the discovery, , by Johann Ham, a pupil of Leeuwenhoek, at , of the spermatozoa, which were at once accepted y as the true generative elements, and were even ed to be minute but completely formed creatures, ng in miniature all the organs of the adult. There se two schools, the Animalculists and the Ovists, pectively maintained the efficacy of the male and products. Nathanael Highmore (1613–1684), a ın of Shaftesbury, England, investigated the tes- e seminal ducts, and the epididymis. His name is ed in the corpus Highmorianum and the antrum of Highmore. Wharton described the round ligament of the uterus as the excretory duct for the female semen, but the question of the hypothetical product was finally settled by Caspar Bartholin, who correctly described the functions of the vulvo-vaginal glands. The mammalian ovum eluded research for a long time. The ovisacs (Graafian follicles) were discovered by Regnier de Graaf (1641–1673), who supposed them at first to be ova, though he seems later to have had a correct idea of their nature. When Naboth discovered the closed follicles of the neck of the uterus, he too supposed that he had found the ova (ovula Nabothi). It is said that Van Horne (1621–1670), professor at Leyden, saw the ovum in 1668, but it was not definitely and unquestionably recognized until von Baer demonstrated it in 1827. Nicolas Andry de Bois-regard (1658–1742) was the first to note the entrance of a spermatozoon into an ovum, and believed that it did this in order to feed. Antonio Vallisneri (1661–1730), professor at Padua, held, on the contrary, that the ovum was necessary for generation, and supposed the spermatozoon to be unessential. Needham first showed that the fœtus was nourished by maternal blood.

In the nervous system considerable advances were made during this period. Although Harvey stated that he was unable to discover the animal spirits, yet he does not seem to have been able wholly to free himself from the influence of the prevailing doctrine. René Descartes (Cartesius, 1596–1650), the eminent mathematician, held that although the soul was immanent throughout the whole body, it must be specially centralized in the pineal gland, that being the only unpaired organ of the brain and situated so as effectually to control the animal spirits contained in the ventricles. He held that the brain is the seat of sensation, motion, and thought, sensation being due to impulses transmitted to that organ by nerves, motion to the contraction of muscles induced by impulses also transmitted by the nerves. He seems to have been aware of reflex action, noting that sensation may cause motion independently of the will. He thus anticipated discoveries made nearly two hundred years later, and was the first to attempt to explain the phenomena of life by purely physical causes. He was a warm adherent of Harvey's doctrine of the circulation. Johann Jacob Wepffer (1620–1695) was the first distinctly to deny that spirits were generated in the cavities of the brain. Pacchioni considered the dura mater as an organ for effecting the circulation of the spirits, and provided it with three muscles and four tendons.

François de le Böe (Franciscus Sylvius, 1614–1672), professor at Leyden, carefully studied the brain and gave true ideas of its interior spaces. His name is preserved in the aqueduct, fissure, fossa, and artery of Sylvius. The fifth ventricle is sometimes called the Sylvian ventricle. Raymond Vieussens (1641–1715), of Montpellier, also investigated the brain. He was the first to describe the anterior pyramids of the medulla oblongata, the olive and the centrum ovale. His name remains in the valve of Vieussens or anterior medullary velum. Duverney described the decussation of the pyramids and the connection of the jugular sinuses with the jugular vein; while Humphrey Ridley (1653–1708) described the restiform body and the circular sinus. Malpighi recognized the functional importance of the gray matter of the brain, and Burrhus (1616–1695) showed that one-fourth of the cerebral substance was a spermaceti-like fat. Much advance was made by the investigations of Thomas Willis (1622–1675), professor at Oxford, who showed that the brain gradually increases in complexity as we ascend the animal series, and considered that its anatomy could only be properly understood by comparative studies. He renamed and rearranged the cranial nerves, separating the nervus intercostalis or sympathetic from the vagus. In his enumeration he made ten pairs, including the first cervical nerve, and classing as single pairs the auditory and facial, and the glosso-pharyngeal, vagus, and spinal accessory. He described the optic thalamus and the corpus striatum.

Osteology continued to be assiduously cultivated It

is from Ole Worm (1588–1654), professor at Copenhagen, that the Wormian bones are named; and Clopton Havers (1692), an English physician, demonstrated the structure of bone (Haversian canals and systems). The structure and action of muscles were specially investigated by Stensen, by Borelli (1608–1679), the celebrated mathematician, and by Hooke (1635–1703), who was the first to recognize the primitive fibrillæ.

Knowledge of the viscera was essentially advanced by John Mayow (1645–1679), of Oxford, who was the first to recognize the true function of the lungs; by Theodor Kerkring of Amsterdam (1640–1693), who described the valvulæ conniventes of the intestine; by Jacques Benigné Winslow (1669–1760), of Paris (foramen of Winslow, posterior ligament of knee joint), and by James Douglas (1675–1742), of London (Douglas' pouch of peritoneum, semilunar fold, etc.).

The eye was specially examined by several investigators, who considered it because of its interest as an optical instrument. Among these we may mention Johann Kepler (1571–1630) the astronomer, who demonstrated the optical properties of the crystalline lens and showed that it is not the seat of vision, as was held by Hippocrates; Christoph Scheiner (1575–1650), who demonstrated the image on the retina and studied the movements of the pupil and the mechanism of accommodation; Descartes, who compared the eye to a camera obscura and suggested that accommodation for near vision was affected by changing the figure of the lens; and Edmé Mariotte (died 1684), who discovered the "blind spot" of the retina.

Another great result of the introduction of the microscope was a vast increase in the knowledge of living things. The source of life and the "vital principle" had been favorite subjects for speculation among the philosophers and poets of antiquity, and the generation of living from non-living matter was held to be demonstrated by many ordinary phenomena, such as the appearance of maggots in putrefying meat and of other insect larvæ in stagnant water. Aristotle even held that tadpoles and snakes were generated from the mud of the Nile. As the laws of development were more carefully studied this "generatio æquivoca" was controverted, especially, in the case of the chick, by Harvey and Fabricius. Francesco Redi (1626–1694), professor at Pisa, by a series of well-conducted experiments, showed that meat did not produce maggots when protected from flies by means of gauze. The doctrine, discarded for the higher forms of life, was, however, revived by the discoveries of the microscope. Antony van Leeuwenhoek (1632–1723), of Delft, discovered that stagnant water and infusions containing animal or vegetable matter swarmed in a few days with minute forms of life, the "infusoria." Nicolaas Hartsoeker (1656–1725), extended these researches and held that the air was filled with animalcula that settled upon plants and from them passed into infusions. This view, afterward conclusively demonstrated by Spallanzani, became known as "panspermatism" and is the forerunner of the modern "germ theory."

The eighteenth century was distinguished rather for its work in elaborating and defining what had previously been discovered than by any great advances in anatomical science. A few remarkable men appeared who advanced generalizations that were afterward to bear fruit, but they were in advance of their time and had but little influence upon their contemporaries. The microscope was still very defective and felt to be a wholly untrustworthy instrument when used with the higher powers. Speculation was rife, and in the absence of direct observation philosophers held the field. Of these should be mentioned Leibnitz (1646–1716), who shares with Newton the renown of inventing calculus. He supposed the universe to be composed of monads, minute, invisible, intelligent constituents of all bodies and beings, that in the human body are governed by a central monad, the soul; as the universe is governed by a central monad, God. He was a firm believer in the uniformity of action of natural causes and the author of the celebrated aphorism, "*Natura non facit saltum.*" Like Paracelsus, Georg Ernst Stahl (1660–1734) scorned anatomy and physiology, holding the soul, which eludes investigation, to be the supreme principle. This doctrine was termed "animism." Friedrich Hoffmann (1660–1742), professor at Halle, taught that the medulla oblongata is the chief reservoir of *æther*, an extremely volatile principle circulating through the vessels and nerves. David Hartley (1705–1757) considered the white medullary substance of the brain as an organ for the secretion of thought, and explained mental processes as caused by minute vibrations (vibratiuncles) of particles in the nerves. Cabanis (1757–1808) had a similar idea, which he expressed rather grossly, comparing the brain to the stomach, sense impressions to food, thought to excrement, etc. Théophile de Bordeu (1722–1776) considered the stomach, heart, and brain as the "tripod of life," regulating the other organs. Finally, there should be mentioned among these speculative philosophers Lorenzo Oken (1776–1851), who held that the entire organic world originated from sea slime formed of microscopically minute vesicles. This is apparently an adumbration of Bathybius and the cellular theory, but appears to be only a chance hit not derived from observation. Oken also independently worked out a theory of the vertebral character of the skull, but many of his speculations were wild and absurd.

It is in this century that we first see the influence of speculative ideas concerning the relation of the structure of man to that of other organisms—ideas which have had a powerful effect upon modern anatomical science. The collection of materials in the field of biology had become so vast that some system of classification became necessary. Steps toward this were first taken in the realm of plants by John Ray (1628–1705), who revived the Aristotelian idea of genera and species and established, as criteria for species, immutability of form and non-fertility with other species. Tournefort (1656–1708) gave a clear definition of a species as individuals having some distinct characteristic, and of a genus as a collection of species resembling each other in structure. It was, however, Karl von Linne (Linnæus, 1707–1778), of Rashult in Smaland, Sweden, professor at Upsala, who, by inventing the binomial nomenclature and applying it widely to all known species of animals and plants, finally established firmly the idea of the immutability of species. He even extended his system of classification to diseases, of which he described three hundred and twenty-five genera. His earlier view was that all the species of plants and animals were immutably created at the beginning of the world, but in his later works he appears to admit a certain amount of variation. In the classification of Linne man was placed at the head of the order Primates, comprising also apes, lemurs, and bats. The recently discovered orang was classified in the same genus with man as "Homo silvestris," and the great naturalist declares himself unable to discern any character by which the great apes can be made generically distinct from man. The race of man himself, *Homo sapiens*, he subdivided into six groups: H. ferus (savage); H. Americanus; H. Europæus; H. Asiaticus; H. asser (negroes); H. monstrosus (abnormal).

The great rival and contemporary of Linne was George Louis Leclerc de Buffon (1707–1788), director of the Jardin du Roi at Paris, and a very prolific writer in all domains of natural history. At first Buffon agreed with Linne as to the immutability of species, but in his studies of comparative anatomy he met with many difficulties, and soon admitted that many variations may arise through changes of climate, food, etc.; that the least perfected species disappear; and finally he even hinted at the possibility that all species of animals were derived from a common stock. While he by no means clearly worked out these ideas, they contain the germs of the doctrine of adaptation and the survival of the fittest, and it is evident that he realized that genera and species are merely human inventions made for convenience in classification.

In like manner we may discern in Maupertuis (1698–1759), president of the Berlin Academy, and a celebrated

mathematician and astronomer, an approach to some modern theories of heredity and variation. He held that all matter has psychic qualities, that the particles of the embryo retain and transmit impressions derived from their parents, chance combinations producing differences which accumulate and thus form new species. It was Charles Bonnet (1720–1793) who first advanced the view that animals can be arranged in a graded series with man at the head. His conception of the series was that it was necessarily linear. Erasmus Darwin (1731–1802), the grandfather of the great naturalist, anticipated some of the views that afterward made his grandson famous. He showed that the structure of animals changes because of their exertions, that many of these changes are transmitted to posterity (transmission of acquired characters), and that many anatomical features of man indicate that his primitive attitude was quadrupedal. Reasoning from such data, he maintained that all warm-blooded animals may have arisen from a single living filament which improved and transmitted its improvements to posterity.

The poet Goethe (1749–1832) was also famous for his morphological researches. Besides the remarkable contribution to botany in which he advanced the hypothesis of the metamorphosis of leaves into parts of the flower and fruit, he also suggested that the skull of vertebrates is composed of modified vertebræ. He recognized the importance and significance of vestigial structures and predicted that a premaxillary bone would be found in the human fœtus.

Widely different from these philosophers who sought to explain the complicated structure of man by the operation of natural forces, were the views of the eminent philosopher and metaphysician Emmanuel Kant (1724–1804), who held that a great gap necessarily exists between organic and inorganic matter, and that while in the latter natural causes prevail, the former is the product of preordained intention, beyond the power of man to comprehend.

Closely allied with these theories of the relation of the structure of man to that of other animals are others regarding his individual development. The imperfections of the microscope and of technical methods prevented an accurate determination of the earlier embryonic stages, and it was imagined that all details of the completed structure are prefigured in the impregnated ovum. This necessarily involved the conclusion that the successive generations of offspring must also be prefigured in the same manner. Bordeu accordingly declared that the semen of Adam must have contained the archetype of all mankind. The whole of the past and present organic life of the globe was held to have been contained in miniature in the first created beings, the successive individuals merely developing by growth from these preformed and structurally complete miniatures. This is the celebrated theory of preformation or encasement (*emboîtement*) which has profoundly interested biologists for the past one hundred and fifty years. It was to this unfolding that Bonnet applied the term *evolution*, a meaning widely different from that now in common use. The great weight of authority at first favored this view, and the celebrated Albrecht von Haller (1708–1777), professor at Berne and Göttingen, a most learned and acute observer, whose reputation was so great that he practically controlled the scientific thought of the latter half of the eighteenth century, even calculated the number of beings encased in the ovary of Eve, the mother of mankind, placing it at about 200,000,000,000.

In opposition to this is the theory of post-formation or epigenesis advanced by Hippocrates and Aristotle, according to which the human body develops from a structureless blastema by successive stages not necessarily resembling the adult individual. This view was revived by Caspar Friedrich Wolff (1735–1794), who published, in 1759, his now celebrated thesis, "Theoria Generationis," which contained an account of accurate observations showing that the organs of the body are not preformed in the fœtus, but developed from membranous sheets (the blastodermic membranes of later embryologists) which are themselves composed of globules or vesicles (cells). These ideas were not accepted by the anatomists of his day. Opposed to them was the great authority of Haller, who declared, "*Nulla est epigenesis*," and they were quite forgotten until fifty years later when Meckel called attention to them. Wolff's name remains to us in the Wolffian bodies or primordial kidneys.

It was from Haller that the doctrine of the vital and animal spirits finally received its *coup de grace*. By a series of most carefully conducted experiments he showed that there exists in living issues a property of motility independent of the nervous or vascular systems. This he termed irritability. Haller is often justly termed the father of physiology, which he himself loved to call living anatomy. His works abound in most excellent anatomical observations. He was an indefatigable worker, dissecting as many as four hundred bodies in the space of seventeen years. He classified structures according to their properties and thus paved the way for Bichat. Many structures have been at one time or another named after him. He was the first to describe the pes hippocampi.

The doctrine of spontaneous generation continued to be discussed. Antonio Maria Valsalva (1666–1723), professor at Bologna, a pupil of Malpighi and a teacher of Morgagni, finding that living forms still appeared in liquids that he had heated and then enclosed in vessels, concluded that they must have originated from the liquids themselves; but this was overthrown by the experiments of Lazzaro Spallanzani (1729–1799), professor at Reggio, Modena, and Pavia, who repeated the experiments with careful precautions and failed to produce life. It was to this observer that we owe the demonstration that the spermatozoa are the constituents of semen essential to fertilization. He showed that the fluid obtained by filtering semen has no effect, also that no exhalations from semen can cause impregnation. Thus were overthrown some of the more fanciful hypotheses of generation.

Throughout the eighteenth century we find isolated attempts at generalizing the complicated structures of the body under a few categories. Almost equally famous with Haller for his erudition was Hermann Boerhaave (1668–1738), professor at Leyden, a skilful anatomist who discovered the sudoriparous glands of the skin, and held that the elementary structures composing the body are vessels and fibres. In Andreas Bonn (1738–1818), professor at Amsterdam, we discern a decided advance. He endeavored to show that all structures can finally be reduced to membranes. Of these he made four classes: (1) the tectorial—skin, mucous membrane, etc.; (2) fibrous—fascia and aponeuroses; (3) synovial, and (4) serous.

The real founder of the science of general anatomy was, however, Marie François Xavier Bichat (1771–1802), who, by his philosophical insight and great energy in research, demonstrated the existence of the tissues of the body in a complete and definite manner. Distrusting the microscope, he made his distinctions by the chemical, physical, or vital properties of each tissue—*i.e.*, by its behavior with various reagents; by its color, density, etc.; or by its alterations in health and disease. Of these tissues or tissue systems he made twenty-one, such as the cellular, the osseous, the fibrous, the arterial, etc. As these tissues are everywhere the same, their diseases must be identical, hence this separation is a proper foundation for pathological anatomy. He considered life to be the composite effect of the separate interaction of the forces resident in these tissues. He died at the early age of thirty-one, from overwork and disease contracted in the putrid dissecting rooms of his day, having effected the greatest advance in anatomical knowledge made since the time of Vesalius.

The anatomy of diseased organs was, prior to Bichat, specially investigated by the illustrious Giovanni Battista Morgagni (1682–1771), who may be said to be the founder of pathological anatomy. He was likewise an ardent investigator in the normal field, as will appear from the large number of structures that bear his name; as the

caruncula Morgagni (middle lobe of prostate), frenum Morgagni (near ileo-cæcal valve), fossa Morgagni (navicular fossa of urethra), hydatids of Morgagni (on fimbriæ of Fallopian tube), columns of Morgagni (in the rectum), etc., etc.

Closely allied to pathological anatomy is surgical anatomy, which made many important advances. John Hunter (1728–1793), an indefatigable investigator, is said to have dissected some thousands of bodies. It is to him that we owe a demonstration of the ease with which collateral circulation is established after ligation of vessels, and the reparative significance of inflammation. He also appears to have been aware of the law of recapitulation in embryology, by which the fœtus of an animal successively passes through forms resembling creatures below it in the animal scale. During thirty years he worked at collecting a museum illustrative of comparative and human anatomy and pathology, which finally comprised some fourteen thousand specimens. It is still considered one of the best extant. It is from him that is named the canal traversed by the femoral artery under the adductor magnus.

Other workers in surgical anatomy were Antonio Scarpa (1752–1832), professor at Modena (Scarpa's triangle, fascia, nerve, ganglion, etc.); Franz Caspar Hesselbach (1759–1816), professor at Würzburg (Hesselbach's triangle); Antonio de Gimbernat (1762–1774), professor at Barcelona (Gimbernat's ligament).

Certain beginnings were now made in the study of the comparative anatomy of the races of man. Pieter Camper (1722–1789), professor at Amsterdam, Franeker, and Gröningen, was a widely learned man; at once an anatomist, a zoologist, a geologist, and an artist, he published in almost every branch of natural history essays remarkable for their originality and research. He was the first to show that the hollow bones of birds are connected with their respiratory apparatus, and wrote an important memoir on the anatomy of the orang, showing that that animal could not be considered as degenerated from man, as had been supposed by some. Noticing that painters took no pains to depict the special physiognomy of the races of mankind, he began to study racial types and invented the celebrated "facial angle," formed by a plane tangent to the most prominent points of the forehead and face and another drawn through the auditory openings and the alæ of the nose. He found that this angle gradually decreases as we descend through the animal kingdom, and concluded that the different races of mankind might be distinguished by it. A wider examination has shown that this view is incorrect, but the method instituted by him of measuring portions of the skull by means of angles has been extensively used in other directions.

Another famous angular measurement was that of the occipital angle of L. J. M. Daubenton (1716–1799), the curator and almost the creator of the splendid museum of the Jardin des Plantes. This was intended to measure the inclination of the foramen magnum, which also varies very much in the animal scale, and has relation to the erect position of the body.

The comparison of crania was systematically pursued by Johann Friedrich Blumenbach (1752–1840), professor at Göttingen, who prescribed for the examination of skulls certain positions that are still in use. He possessed a very large collection of crania, and made important generalizations regarding the races of men. While considering these as very numerous, he grouped them in five principal divisions, to which he applied designations that held for more than a century. Three of these he considered primary: the Caucasian, Mongolian, and Ethiopian; two secondary or intermediate: the American and Malayan.

Logically connected with this, although not developed until early in the nineteenth century, was the curious doctrine widely known as "phrenology," though its founder, Franz Joseph Gall, of Baden (1758–1828), called it "organology." Gall was by no means ignorant of the gross anatomy of the brain, but he knew nothing of its histology and supposed the white substance to be equally active with the gray in intellectual processes. Noticing the convergent fibres of the corona radiata, he conceived the idea that the brain was a series of pyramidal "organs" whose bases were superficial and whose apices were deeply buried in the medulla oblongata. These organs correspond to supposed functions of the mind, concerning which he appears not to have had any well-digested philosophical ideas. He believed that he had demonstrated that the organs varied in size and external prominence in different individuals to such an extent that character and mental aptitudes could be told by palpation of the protuberances of the cranium, due allowance being made for the natural bony prominences common to all skulls. Gall described twenty-seven organs, his pupil Spurzheim added ten more, and his followers in this country increased these by six, making a total of forty-three. When the nerve cells were discovered and it was seen that the gray matter was the effective working element of the brain, and that the surface projecting externally was only a small portion of the cortical area, phrenology had no longer a satisfactory reason for existence as a doctrine. However, it retained a considerable vogue for a time, being especially diffused by peripatetic lecturers whose influence in spreading among the people a knowledge of the physical basis of mind was often considerable.

A correct appreciation of some parts of the body was now greatly aided by the advancement of chemistry. Oxygen was discovered by Priestley in 1774. Its true significance was not, however, understood until the demonstrations of Lavoisier (1743–1794), who showed its importance in combustion and respiration. Antoine François de Fourcroy (1755–1809) was the first to investigate the composition of organic products, and William C. Cruikshank (1745–1800) discovered urea.

The delimitation of the organs of the body in the living, which may be said to be an anatomical art, was now much advanced by the invention of percussion by Joseph Leopold Auenbrugger (1722–1809), a physician of Vienna.

The advances made in the knowledge of the grosser structures were rather refinements upon what was already roughly sketched out than incursions into new fields. Josias Weitbrecht (1702–1747) was the author of a celebrated treatise upon syndesmology that contains the elements of our knowledge of ligaments to-day. Exupère Joseph Bertin (1712–1781), an academician of Paris, described the ilio-femoral ligament, the sphenoidal turbinated bones, and the septa of the kidney. Bernhard Siegfried Albinus (Weiss, 1697–1770), professor at Leyden, greatly improved myology by the publication of magnificent colored plates showing the muscular system most carefully delineated. He was also the first to demonstrate by injections the connection between the vascular systems of the mother and the fœtus.

In the vascular system considerable advances were made. Gilbert Breschet (1784–1845) described the veins and canals of the diploë; William Hunter (1718–1783), brother of John and lecturer at Middlesex Hospital, demonstrated the arrangement of the lymphatics and showed them to be absorbents. He was also the author of a paper on the anatomy of the gravid uterus which is the basis of all subsequent descriptions. It particularly notes the changes in the cavity and the formation of the decidua. He carefully described the descent of the testes, and his name is often coupled with the round ligament of the uterus and the gubernaculum testis. William Hewson (1739–1774) also contributed to knowledge of the lacteals and lymphatics, tracing them in birds, fishes, and reptiles. Paolo Mascagni (1752–1815) professor at Siena, Pisa, and Florence, published elaborate studies of the lymphatics which were afterward continued by Vincenz Frohmann (1794–1837), professor at Heidelberg and Louvain.

In the realm of the nervous system considerable advances were made. Giovanni Maria Lancisi (1654–1720), the teacher of Morgagni and physician to the Pope, described more carefully than had been done before some features of the brain (nerves of Lancisi). Alexander

Monro I. (1697–1767), one of Boerhaave's favorite pupils, professor at Edinburgh, gave an excellent description of the bones and nerves; but his fame was eclipsed by that of his son, Alexander Monro II. (1733–1817), also professor at Edinburgh, who was especially noted for his work in the anatomy of the brain (foramen of Monro, sulcus of Monro). He was the first to attempt a description of all the bursæ mucosæ of the body. Félix Vicq d'Azyr (1748–1794), an academician of Paris, demonstrator at the Jardin du Roi, and excellently versed in comparative and veterinary anatomy, also studied the brain and added to our knowledge of the minute structure of the white and gray matter (line and bundle of Vicq d'Azyr). Johann Christian Reil (1759–1813) first described the insula or island of Reil. Luigi Rolando (1773–1831), professor at Turin, distinguished himself by careful researches in both the brain and spinal cord (fissure, gelatinous substance, and tubercle of Rolando).

The cranial nerves received renewed attention. It was Johann Jacob Huber (1707–1778), professor at Göttingen and Cassel, who clearly pointed out the error of Willis in placing the suboccipital nerve among the cranial nerves, though Haller also commented upon this. Carl Samuel Andersch (1732–1777) distinguished from each other for the first time the ninth, tenth, and eleventh nerves, and discovered the petrous ganglion. Samuel Thomas Sömmering (1755–1830) was the first to separate the facial and the auditory nerves, thus establishing the twelve cranial nerves as we now enumerate them. This enumeration, usually ascribed to Sömmering, was really first definitely proposed, in 1794, by Johann Christoph Mayer (1747–1801). The little intermediary nerve that makes the tale of the cranial nerves absolutely complete was first described by Heinrich August Wrisberg (1739–1808), professor in Göttingen, who also made other discoveries, his name remaining in the lesser cutaneous nerve of the arm, in one of the cartilages of the larynx, and in a small ganglion in the substance of the heart.

Johann Friedrich Meckel, the first in a succession of famous anatomists of the name (1714–1774), professor at Berlin, gave especial attention to the trigeminus and facial nerves and was the first to describe the sphenopalatine ganglion and the space in the dura mater that contains the ganglion of the trigeminus. The latter structure appears to have been first recognized as a ganglion by J. Lorenz Gasser, of Vienna, about 1750. Meckel had previously described it as a tænia nervosa, and Vieussens as a plexus ganglioniformis, and Eustachius had figured it in his celebrated plates. It was named by Hirsch as the ganglion Gasserianum, in honor of his illustrious master.

The tympanic nerve and the jugular ganglion of the glosso-pharyngeal nerve were first described by Johann Ehrenritter (about 1775), professor at Vienna, although from the exact researches of L. L. Jacobson (1783–1843), professor at Copenhagen, the nerve usually bears his name. To the latter author is also ascribed the discovery of Jacobson's organ in the nasal fossæ of the sheep and of its vestiges in man.

A physiological discovery of much importance in the elucidation of the anatomy of the nervous system was that of the distinction between the motor and the sensory roots of the spinal nerves made by Georg Prochaska (1749–1820), professor at Prague. This was afterward clearly established by the Edinburgh anatomist, Sir Charles Bell (1774–1842), who also showed conclusively the motor function of the facial nerve. The posterior thoracic nerve is often called the external respiratory nerve of Bell.

In the anatomy of the viscera there should be mentioned the investigations of Lorenz Heister (1683–1758), professor at Altorf and Helmstadt, who discovered the spiral valve in the neck of the gall bladder; Antoine Ferrein (1693–1769), professor at Paris, who investigated the kidney and the organs of voice; Joseph Lieutaud (1703–1780), who described anew the bladder, mentioning for the first time the trigone. He was famous in pathological anatomy, publishing a work based on the examination of twelve hundred bodies. Johann Nathanael Lieberkühn (1711–1765) was famous for injected preparations and made some excellent observations on the minute anatomy of the intestinal mucous membrane, including the villi and glands. Johann Christian Rosenmüller (1771–1820), professor at Leipsic, investigated the nasal fossæ and the annexes of the uterus. The anatomy of the vocal organs was also investigated by Denis Dodart (1634–1707), who held that the voice was caused by a vibration of the air in the larynx, while Ferrein held that it was due to a vibration of the vocal chords. Giovanni Domenico Santorini (1681–1737) also paid especial attention to the organs of voice, to the emissary veins of the cranium, and to the muscles of the face (corpuscula Santorini of the larynx, emissaria Santorini, cartilage of Santorini in the nose, musculus risorius Santorini of the face).

The anatomy of the eye was especially enriched by important discoveries during this period. François Pourfour du Petit (1664–1741) paid especial attention to the lens and described the lacunar spaces in the suspensory ligament, often called the canal of Petit. Jacob Hovius, a Dutch anatomist (about 1702), appears to have discovered the chorio-capillary layer of the chorioid, afterward accredited to Ruysch (tunica Ruyschiana). He also described the venæ vorticosæ. Eberhard Jacob von Wachendorff discovered the pupillary membrane in 1740, though it is possible that it may have been previously known to Albinus. Jacques René Tenon (1724–1816), an academician at Paris, described the fascial attachments of the eyeball more accurately than had been heretofore done (capsule of Tenon, space of Tenon). In some cases controversies arose as to priority of discovery: the separable posterior layer of the cornea, which was apparently seen and described by Benedict Duddell, an oculist of London in 1729, was rediscovered by Jean Descemet, professor at Paris (1732–1810), and at about the same time by Pierre Demours (1702–1795), demonstrator at the Jardin du Roi. The most important treatise on the anatomy of the eye that appeared during the last century, and the basis of all that has since been published, is that of Johann Gottfried Zinn (1727–1759), professor at Göttingen (zonule of Zinn, ligament of Zinn). Felice Fontana (1730–1805), professor at Pisa, described the attachment of the iris and the trabecular tissue since known as the spaces of Fontana. Johann Gottfried Berger (1659–1736) was probably the first to indicate the existence of the orbicular muscular fibres of the iris.

The profound and exact researches in the anatomy of the internal ear made by Domenico Cotugno (Cotunnius, 1736–1822), professor at Naples, were probably the most significant of any made in this region during the century. He also investigated the pathological anatomy of the skin, and was the first to demonstrate by boiling the existence of albumin in urine. His name remains in the liquor of Cotunnius or perilymph, the aqueduct of Cotunnius (aqueductus vestibuli), and the nerve of Cotunnius (naso-palatine nerve).

The great advance in the anatomical sciences during the nineteenth century has been primarily due to what may be termed their secularization, that is to say, to the extension of research by placing it in the hands of all students inclined to pursue it. At the beginning of the century the old method of teaching by means of demonstration was still almost everywhere pursued. Students were rarely able to dissect, and the procuring of bodies for anatomical purposes was beset with difficulties. In 1827 the University of Edinburgh, with nine hundred students, made dissection compulsory, and this excellent example was immediately followed by London, Liverpool, and Dublin.

In consequence of this the demand for human cadavers was greatly increased and the price so enhanced that unscrupulous persons were tempted to procure them by surreptitious means. Grave-robbing, hitherto exceptional, now became common, and in every large city where medical schools flourished there became established a set of ruffians who made it their business to supply dissecting tables with bodies ruthlessly torn from the

graves to which they had been consigned by sorrowing friends. The large iron cages built over many graves and the formidable enclosures of cemeteries of this period in England and Scotland testify to a widespread fear, and a glance at the literature of the early part of this century will show what an effect this ghastly practice had upon the popular mind. It would be easy to give many authentic examples which were not confined to common law-breakers, for, led by a youthful love for adventure or perhaps in some cases by a real zeal for knowledge, bands of students and even of professional men broke into cemeteries and violated graves. The law required of medical practitioners a competent knowledge of anatomy, and yet denied them the means necessary for attaining it.

The absurdity of such a position was not realized until the shocking disclosures of the trial of Burke and Hare at Edinburgh in December, 1828. It was shown that these scoundrels had murdered at least sixteen persons for the purpose of selling their bodies. Similar cases were those of Bishop and Williams, executed in London in 1831. Bishop had followed his nefarious trade for twelve years, and had sold to the colleges at least five hundred bodies, some of which were doubtless those of murdered victims. The excitement occasioned by these trials led to a parliamentary inquiry and the passage of the Warburton anatomy act, August 1, 1832, which legalized dissection under certain restrictions and provided for turning over to the medical schools the bodies of unclaimed paupers. Upon the continent of Europe similar regulations had already been for some time established.

The cooperation of a large number of additional workers led to greater precision in all anatomical work, to the accumulation of a vast body of additional facts, and finally to a more comprehensive and satisfactory generalization of the principles that underlie and affect anatomical structure. The idea of the filiation and progressive development of all organic beings—considered a wild and unsubstantial hypothesis during the eighteenth century—has constantly gained in weight and force by increasing knowledge of existing forms—comparative anatomy; of extinct forms—palæontology; and of individual development—embryology. This increase in knowledge has been greatly aided by improvement in the microscope, which has become an efficient and reliable instrument of research, and by the application of chemical and mechanical methods to the preparation of tissues for microscopical examination, which methods are grouped together under the term of microscopical technology.

Fragments from the writings of some of the ancient philosophers, notably Empedocles and Democritus, show that ideas of adaptation and mutability of forms had occurred to them. So, too, we find traces of such speculations in the writers of the last century: Buffon, Erasmus Darwin, and Goethe. These ideas were developed into a coherent system by Jean Lamarck (1744–1829), professor of natural history at the Jardin des Plantes and one of the most acute minds of his age. His force as a naturalist will be appreciated when we recall that we owe to him the division of animals into vertebrates and invertebrates, and also the separation of the groups crustacea, arachnida, and annelida. He invented the term biology for the sciences of life, though Treviranus suggested it during the same year (1802). In his "Philosophie zoologique" is first scientifically stated and systematically supported the mutability of species and their origin by adaptation. Lamarck thought that such changes were caused mainly by the needs of the animal and the use and disuse of organs, becoming cumulative in the race by the transmission of acquired characters. For these changes three factors—space, time, and matter—are requisite; and these are produced by nature in unlimited quantities, hence the multiplicity of organic forms. He was the first to conceive the ancestral record of man as a branching tree instead of a series of ascending steps. The formation of the lowest animals from mucilaginous matter was suggested by him, prior to Oken's sea-slime theory

The views of Lamarck, although widely accepted in a modified form by the naturalists of to-day, were very coldly received at that time. This was largely due to the powerful opposition of Georges Cuvier (1769–1832), professor at the Musée d'Histoire Naturelle at Paris, and the foremost naturalist of his time. He greatly advanced knowledge of both living and extinct forms of animal life and has been called the founder of comparative anatomy and of palæontology. From a modern point of view his work is most contradictory. While he founded a true natural system in zoology, showing that the forms of the animal world may be reduced to a few distinct types, he yet upheld the absolute fixity of species. While investigating fossil remains with an ardor and success never before equalled, he advanced the theory that all organic living forms had been repeatedly wiped out of existence by unexplained cosmic catastrophes. In opposition to the epigenetic views of Wolff and others, he also upheld the evolution of the embryo from a preformed miniature. Throwing the weight of his great influence against the development theory, he was able, owing to the lack of data, to discredit it almost wholly, and to control the trend of biological thought until after the middle of the century.

A growing revolt against this domination was, however, caused by the advances of knowledge. Gottfried Treviranus of Bremen (1776–1837) was among those who protested against making the biological sciences a mere catalogue of names, as was done by Linne and Cuvier, holding that it is possible to discover a philosophy of nature. He suggested the theory of compensatory development, deficiency in one part being made up by excess in another, and recognized that the environment reacts upon the individual. The wider and more complex the environment the higher must be the grade of the organism.

Étienne Geoffroy St. Hilaire (1772–1844), professor of zoology at the Jardin des Plantes, and the author of remarkable treatises on teratology and philosophical anatomy, was also an opponent of Cuvier's views. He held that the principal factor in the transformation of species is changing environment, acting particularly through its effect upon respiration. His teratological studies led him to conclude that the course of development of organic forms is not necessarily gradual, but that sudden and considerable changes may occur, thus opposing the Leibnitzian doctrine in favor of so-called "saltatory" evolution.

A collateral influence in favor of uniformity of action was afforded by Sir Charles Lyell (1797–1875), who by a cogent marshalling of ascertained facts finally overthrew (1830) the Cuvierian doctrine of catastrophes in geology. He also published in 1863 an important treatise on the "Antiquity of Man," in which he showed that human remains are found in the strata of quarternary or perhaps earlier times, and that they in general indicate a lower organization than that of modern Europeans.

Advances in knowledge of embryological development continued and afforded support to the new hypotheses. Johann Friedrich Meckel (1781–1833), professor in Halle, grandson of the previous anatomist of the same name, called to notice the forgotten writings of Wolff, and himself made important observations. To him is due the discovery of Meckel's cartilage in the lower jaw, and of Meckel's diverticulum, the vestigial stem of the omphalomesenteric duct. He seems to have been the first clearly to formulate what is now known as the law of recapitulation, stating that the original form of all organisms is the same, and that in process of development the higher assume as transitory stages the permanent forms of the lower. This was even more definitely stated by Serres (1842) in his "Précis d'anatomie transcendente," who declared comparative anatomy to be an arrested embryology, and embryology a transitory comparative anatomy. Haeckel calls this the "fundamental biogenetic law," and states it thus: "Ontogeny is a short and quick repetition or recapitulation of phylogeny, determined by the laws of inheritance and adaptation."

Under the influence of Ignatz Döllinger, of Würzburg, who was an ardent embryologist, and who revived the use of the microscope, arose Christ. Pander (1793–1865), who studied the development of the chick and confirmed Wolff's theory of the germinal layers, and Carl Ernest von Baer (1792–1876), professor in Dorpat, St. Petersburg, and Königsberg, who discovered the mammalian ovum and the chorda dorsalis. He pointed out that the development of the individual is an advance from a generalized to a more specialized form, and brought the theory of the blastodermic layers to nearly its present condition.

The correction of chromatic and spherical aberration in the microscope was finally practically effected about 1824, and the instrument was soon used in research with more certain results than had hitherto been possible. This led to a reinvestigation of the tissues of the body and the formulation of the important doctrine known as the *cell theory*. That organic forms had for their basis minute elementary units had been suspected by many observers, especially in the domain of vegetal anatomy, the cellular structure of plants being more apparent than that of animals. The speculations of the Greek philosophers in this field were wholly metaphysical, and it was not until after the invention of the microscope (1665) that Robert Hooke first saw and figured the structure of cork as a series of minute honeycomb-like cavities, to which he applied the name of *cells*. In 1671, Grew and Malpighi separately presented to the Royal Society of London papers advancing the view that plants are composed of vesicles with fluid contents and rigid walls, and of vessels or tubes. Wolff (1759) supposed the primitive elements of plants to be gelatinous globules or droplets, Moldenhawer (1812) showed that each plant cell has its own distinct wall, Turpin (1826) held that each has an individuality of its own, Leeuwenhoek, Fontana, and others appear to have seen the cell nucleus, while Robert Brown (1831) was the first to recognize it as a constant normal constituent. Schleiden (1838) considered the nucleus to be the generator of the cell, calling it the cytoblast, and also showed that all parts of plants are composed of cells or their derivatives. Dutrochet, as early as 1824, advanced the idea that animals and plants are composed of cells, but it was reserved for Theodor Schwann (1810–1882), professor at Louvain, to demonstrate this in a satisfactory manner in 1838–39. At this time a cell was supposed to be a hollow vesicle having a wall and a cavity containing fluid.

The constitution of the cell now received attention. The name *sarcode* was applied by Dujardin (1835) to the gelatinous matter composing the body of rhizopods, while a similar substance in plants was called by Mirbel *cambium*, by Schleiden *mucilage*, and finally by Hugo von Mohl *protoplasm*, a term previously used by Purkinje for the formative tissue of young embryos. The practical identity of these substances was shown by Max Schultze and De Bary, and the name protoplasm was henceforth used for the active living matter of both plant and animal cells.

Further observation of young cells now showed not only that they had no permanent cavity, but that the cell wall, supposed by earlier observers to be essential, was often absent. Reduced to its simplest expression the definition of a cell was then formulated by Leydig (1856) as "a mass of protoplasm provided with a nucleus."

Schwann and the earlier observers believed that cells originate in a structureless blastema as crystals form in a mother liquor. Cellular division was first observed by Mohl in algæ (1835), in other plants and in animals by Nägeli, Kölliker, Bischoff, and others, and finally, in 1855, Virchow was able to formulate his famous maxim, "*Omnis cellula e cellula*," which had been, however, anticipated by Goodsir, who declared in 1845, "No cells without pre-existing cells."

The phenomena of embryology were now brought under the category of cell division. The ovum was recognized as a cell by the immediate followers of Schwann, with the "germinal vesicle" of Purkinje (1825) as its nucleus. The segmentation of the ovum, first definitely described (in frog's eggs) by Prevost and Dumas (1824), was now seen to be a case of cell division. Ova were already known to develop from the body of the mother—a similar development was shown for the spermatozoa by Kölliker (1841). The structure of the body was thus shown to depend upon cells derived from the parents.

The resemblance of infusoria to cells was first noted by Meyer in 1839, and in 1845 Siebold classed them as unicellular beings, naming them protozoa.

The cell theory as formulated by Schwann and his immediate successors may then be formulated as follows:

1. All organized beings, including man, are composed of minute microscopical units that have independent life and multiply by division.

2. The primitive form of each individual, as well as the permanent form of the lowest creatures, is a single cell.

The influence of this doctrine upon all departments of anatomy was very great. The human body was wholly re-examined to ascertain the arrangement and relations of its elements. Thus the department of histology became elevated to a high rank, affording scope for thousands of investigators. In pathological anatomy also great advances were made, and the investigation of disease was placed upon a sound scientific basis. In this field Rudolph Virchow, by the publication of his classical treatise "Cellular Pathology," performed most valuable service.

Hand-in-hand with the investigation of the anatomical constitution and the relations of cells proceeded the development of technical methods and the discovery of the behavior of cells toward various reagents. These have greatly aided microscopical research, and account in a very large measure for the immense progress in this field as compared with any previous period of equal extent. In 1842 Stilling invented the cutting of thin serial sections which can be examined by transmitted light. By this means it became possible to reconstruct the interior fabric of the most delicate organs. By the improved instruments of recent times there can now be cut sections as thin as from 5 μ to 1 μ ($\frac{1}{5000}$ to $\frac{1}{25000}$ of an inch). The clearing and mounting of sections was invented by Lockhart Clarke in 1851, hardening by dehydration with absolute alcohol by H. Müller in 1856. These at once greatly facilitated manipulation and a wider study of microscopical preparations. The immediate result was the discovery, by Remak and Deiters, of the processes of nerve cells. Carmine staining was invented by Gerlach in 1858, and led to knowledge of nuclear structure and the discovery of nuclei where none had been hitherto suspected. Silver staining in solution appears to have been first invented by von Recklinghausen in 1860, although staining by the solid stick had been previously used by His and others; it led to a clearer knowledge of cell boundaries and contents. The staining by aniline dyes and the method of double staining were first applied by Waldeyer in 1863, and led to important advances in knowledge of cell structure and cell division. Max Schultze, in 1865, first devised staining by perosmic acid, which resulted in clear conceptions of the medullary sheath of nerve fibres. Other means of differentiating nervous tissue were found in the gold stain of Cohnheim (1866), the palladium stain of F. E. Schultze (1867), and the remarkable bichromate of silver stain of Golgi (1873). These have made it possible to trace the processes of nerve cells to their finest ramifications and have given to neurology the remarkable precision possessed by it to-day, a precision never dreamed of by the anatomists of the last century. Embedding in celloidin was invented by Schiefferdecker in 1882, the hæmatoxylin mordant method which has given such excellent results in tracing nerve tracts, by Weigert (1884) and Pal (1887). The methylene blue method of Ehrlich, to which are due some of the most important of the recent discoveries, was invented in 1886. Finally should be mentioned the improvements in the instrument itself by

the invention, in 1887, by Abbe of Jena, of apochromatic lenses of wide aperture and homogeneous immersion, by which clearer definition is obtained together with more accurate correction of chromatic aberration The magnifying power with good definition, which was, in the earlier half of the century, limited to less than 500 diameters, is now from 1,000 to 1,500 diameters.

Besides the microscope, other optical inventions and discoveries have greatly aided the extension of anatomical knowledge. Among these should be mentioned the ophthalmoscope, invented in 1851 by Hermann von Helmholtz (1821–1894), professor at Berlin; the laryngoscope, invented in 1858 by Johann Nepomuk Czermak (1828–1873), professor at Prague and Leipsic; and the astounding discovery, made in 1895 by Wilhelm Konrad Röntgen (born 1845), professor at Würzburg, of the so-called *x*-rays, by which actinic shadows of the more solid parts of the living human body can be cast upon a photographic plate.

The question of the spontaneous generation of the cells of the body and of unicellular forms of life was naturally considered in connection with theories of development and structure. The experiments of Spallanzani and Needham on the generation of infusoria were found to be not always conclusive when repeated by others, and it was generally held that cells might generate *de novo* in the bodily fluids. This had great bearing upon questions in pathological anatomy.

A new light was thrown on this by the discovery, in 1836, by Cagniard de la Tour and by Schwann, of the *yeast plant*, which by its rapid multiplication spreads from a small quantity of leaven throughout a large mass. F. E. Schultze had previously shown that exclusion of air prevented fermentation. This led to the theory of chemical ferments (Liebig), which was in 1857 overthrown by Louis Pasteur (1822–1895), who showed that fermentation and putrefaction are due to the presence of minute living spores. The parasitic character of many disorders was shown, and it was also proved that the supposed formation of pus cells in the tissues of the body was due to the multiplication of living corpuscles already existing there or the transmigration of others from the blood-vessels (diapedesis, Cohnheim, 1867). The experiments of Pasteur, Tyndall, and others served to show that ordinary air is crowded with living particles that reproduce their kind when placed in suitable conditions. Hence arose the so-called "germ theory" of the origin of many diseases, which has had an important influence upon the development of pathological anatomy.

As an offset to the all-pervading germs came, in 1884, the discovery by Metschnikoff, professor in Odessa, that white blood corpuscles and cells of lymphoid organs have the property of destroying foreign organisms that may be introduced into the body (phagocytosis).

The most significant event in the history of anatomy, as in that of other biological sciences during the nineteenth century, was doubtless the publication, in 1859, of the "Origin of Species" by Charles Darwin (1809–1882). As early as 1837 Darwin began to collect data with reference to the variation of structure in animals and plants, and with a reticence as unusual as rare withheld his speculations until they were ripened by mature thought and corroborated by numerous experiments. The great advance that he made upon the theory of Lamarck was in recognizing the "struggle for existence" as the potent factor in producing change by inducing the "survival of the fittest" forms to reproduce their kind. Similar views were produced at about the same time by Alfred Russell Wallace, the distinguished naturalist. Darwin applied his principles to the structure of man in his work "The Descent of Man," published in 1871.

The careful and cautious character of Darwin's work, fortified as it was by the most exhaustive and minute investigations, caused it to be received far differently from that of his predecessors. The human organism evolved throughout countless ages was now seen to be a cosmic phenomenon of vast importance and significance, not an isolated and special matter dependent on the action of some unknown and incomprehensible power. The influence exerted upon all departments of anatomy was very great. No longer could the structure of man be considered by itself, it must be illustrated and interpreted by that of all other creatures. The blurred and forgotten pages of the book of life on the globe must be deciphered to give man a clew to the meaning of his own bodily form. Comparative anatomy and palæontology thus became powerful coadjutors to human anatomy, and the study of development, under Meckel's law of recapitulation, became more essential than ever.

The study of the varieties of man assumed a new importance. The groundwork of a rational anthropology had already been laid by Andreas Adolf Retzius (1796–1860), professor at Stockholm, who invented the cephalic index and introduced the principle of indexes for the classification of measurements. Other workers in this field were the Americans; Samuel G. Morton, J. Aitken Meigs, Nott and Gliddon, and Jeffries Wyman; the British; Pritchard, Lawrence, Barclay, Flower, and Tylor; the Germans; Spix, Lucae, Welcker, Ranke, Ihering, and Schmidt; and in France; Dumoutier, Jacquart, Quatrefages, and especially Paul Broca (1824–1880), who founded the Paris Société d'Anthropologie (1859), and by his great intellectual activity reduced to system the somewhat irregular methods in use before his time. Similar societies were formed at most scientific centres: London—1863, Berlin—1869, Vienna—1870, Washington—1880.

A more careful search disclosed the remains of man in strata of geologic epochs far more distant than had hitherto been imagined. Thus, in the grotto of Engis, near Liège, they were found (1835) in conjunction with the bones of the mammoth and the cave bear; in the valley of the Somme, Boucher de Perthes discovered (1846) implements of human manufacture in strata of unquestionable quaternary origin; in the Neanderthal, near Düsseldorf, there was found (1857) a remarkable ape-like skull associated with bones of the cave bear; at La Naulette, in Belgium, near Dinant, a fragment of a human jaw of very low type, together with bones of the mammoth and woolly rhinoceros; and in 1886, in the grotto of Spy, bank of the Orneau River, in Belgium, were unearthed two skeletons associated with similar bones of extinct animals. Other discoveries of like nature were made in Kent, England, near Prague, in Moravia, in the Balkan peninsula, in Bohemia, at many places in France, in the pampas of South America and in Patagonia, the latter being associated with the huge carapaces of the glyptodon. The most remarkable find of all was, however, that of Dr. Eugène Dubois, who during explorations in Java (1890–1895) discovered a fossil skull cap, a femur, and two molar teeth embedded in rock and associated with the remains of extinct animals belonging to the Pliocene epoch. These remains appear to be transition forms between those of the higher apes and the lowest existing men.

At the time of Darwin the intimate structure of the cell was little understood or considered, but the researches of Oscar Hertwig, van Beneden, Flemming, and many others have shown the great importance of this branch of anatomical inquiry, and it is about the problems here found that the principal discussions of more recent times have been raised.

In 1866 the lowest form of a cell was considered to be simply a mass of structureless protoplasm endowed with vital properties, the cell membrane and the nucleus having been successively dismissed as non-essential elements. Protoplasm was considered as a homogeneous, semi-fluid substance, with little or no trace of organization, whose chemical constitution was only approximately known, but was believed to be highly complex. Some daring spirits ventured to surmise that it might be possible to produce protoplasm in the chemical laboratory.

The elaborate investigations of recent years have shown the futility of such a pretension, indicating that protoplasm has an almost inconceivable instability, that it differs in composition in different cells, in different parts of the body, and under different stimuli. The substances of which it is composed are among the most complicated

known to chemistry, and there is reason to suppose that in the living body it is much more unstable than in the cadaver. There appears to be a wide distinction to be made between those *organic* bodies that are products of secretion and excretion such as sugar, starch, and urea, and the *organized* bodies such as the different protoplasms that are produced by the slow and peculiar processes of biotic growth.

The morphological character of protoplasm has also been found to be much more complicated than had been supposed. First granules were observed, then striations, then vacuolizations. The appearances being often contradictory and varying much with varying conditions, it is not surprising that they have led to diverse views as to its structure. These are by no means settled as yet, but they may be succinctly grouped as follows:

1. The *reticular* theory, first brought clearly forward by Karl Heitzmann (1830–1896) in 1873, and still maintained, under various modifications, by a great number of cytologists. According to this all protoplasm is composed of two substances: a more solid network—the cytoreticulum or spongioplasm, and a more fluid interstitial substance—the cytolymph, hyaloplasma, or enchylema. The granules observed in cells, when not foreign inclusions or masses of dead protoplasm, are the intersections of this network. There is no doubt but that the great majority of cells, when fixed by the usual methods and treated with staining reagents, show some traces of such a reticulum.

2. The *filar* theory, advocated by Flemming (1887), who by studying cells unaffected by reagents concludes that they are structurally composed of free threads, the cytomitom, not combined into a reticulum but often containing numerous nodosities.

3. The *granular* theory, first brought forward by Arndt, and afterward advocated by Altmann (1887). This supposes protoplasm to be formed of granulations embedded in a homogeneous basis substance. These granules, Altmann's bioblasts, are held to be themselves morphological units of a still lower order than the cells. Special means of preparation are required to demonstrate them.

4. The *alveolar* theory, of Bütschli (professor at Heidelberg, 1889) and his school, who hold that the structure of protoplasm is like that of a fine viscous froth or foam, that is to say, composed of alveoli with extremely thin walls. This structure is believed to be a physical consequence of the peculiar conditions of tension and surface flow possessed by the substance, and may be imitated by emulsions of thickened oil and various salts. This view attempts to explain the appearances of the other theories either by the optical conditions under which the alveoli are viewed or by the reaction of the reagents employed. To demonstrate the alveoli in perfection the protoplasm must be living and the best attainable optical conditions secured. Under such circumstances they are seen actively to change their forms and relations to each other, these phenomena being so swiftly evanescent that it is impossible accurately to represent them in a camera drawing,—while the hand is tracing one part another is rapidly changing.

Attempts have been made to reconcile these conflicting views. Kölliker considers that the different appearances are due to different states of development of the protoplasm. In young cells he supposes it to be homogeneous and without structure, formed of a mixture of various substances possessing different degrees of contractility and solubility in acids. In such a medium vacuoles will sooner or later appear. If these are numerous and small the structure of the protoplasm will be alveolar; if the walls of the alveoli break it becomes reticular; if the threads of the reticulum break it becomes filar. Doubtless this view may assist us in certain interpretations, yet it must be said that recent observations tend to show that even the earliest ovum does not possess a homogeneous structure.

Among the differentiations of the protoplasmic mass of the cell the nucleus has been the most successfully investigated. Flemming was the first to show that it contains several substances, one of which, from its affinity for coloring matters, he named chromatin. The phenomena of indirect cell division (mitosis, karyokinesis) were first connectedly observed by Anton Schneider in 1873, although Balbiani and others had previously noted separate stages. The nuclear reticulum which plays so important a part in this process was first noticed by Frommann in 1865. The fragmentation of this into separate sections or chromosomes was shown by Balbiani and Carnoy. These again are separable into granular bodies, to which the name of chromomeres has been given by Fol (1891). Other investigators who have greatly advanced the knowledge of this process are Strasburger, Boveri, Oscar and Richard Hertwig, van Beneden, and Rabl.

The great advance made in theoretical chemistry by the atomic theory of Dalton (1808) is well known. Although atoms and molecules have never been seen, the hypothetical constitution of bodies supposed to be formed by them is now definitely stated and predicted. The signal success of this theory has led to similar speculations regarding the constitution of protoplasm. The first of these was that of Nägeli, who in 1884 propounded his *micellar hypothesis*. According to this, protoplasm is composed of an immense number of "micellæ," elementary units of a crystalline character, far beyond the limits of microscopic vision. As molecules are formed of atoms, so micellæ, units of a next higher order, are formed of molecules. The peculiar physical properties of protoplasm, its imbibition of water, etc., are explained by the arrangement and affinities of the micellæ.

The hypothesis of Nägeli has led the way to a number of others of a similar character by De Vries, Wiesner, Haeckel, Hertwig, Roux, and Weismann. These have generally been directed toward explaining by this means the phenomena of heredity. By a series of beautiful experiments (1884) Oscar Hertwig has apparently succeeded in showing that the physical substance upon which this transmission of characters depends is the chromatin found in the cell nucleus.

Starting with this for a basis Weismann, in various publications from 1875 to 1894, has propounded an elaborate theory by which he attempts to explain the phenomena of hereditary resemblance. According to this, the chromatin is a structure of almost inconceivable architectural complexity. In his system Weismann, following Nägeli, names it "idioplasm," and supposes it to be composed of groups called "ids," corresponding to the chromomeres seen under the microscope. During the segmentation of the ovum or any other cell division, these ids also divide, so that they are distributed to each cell throughout the body. The ids are themselves composed of lesser units called "determinants," because they determine the histological character of the cells within which they dwell. There are as many kinds of determinants as there are parts of the body capable of being different. Determinants are themselves compound, being composed of "biophores," or ultimate units that control the vital activities of the cell.

In the segmentation of the ovum certain of the cells divide so that each division retains exactly similar determinants and thus remains equal in capacity to the original ovum. Such *duplicative* division produces the tissue denominated "germ plasm" found in the nuclei of the germinal cells of the ovary and testis. Other of the cells divide by a *differential* division by which determinants of different kinds are sorted out, grouped together, and relegated to different cells. These are the somatic or body cells from which the general tissues of the body are formed. Since the germ cells and body cells separate at the earliest stage, no modification of the latter can affect the germ plasm, hence it is denied that characters acquired by the body cells can be transmitted to the offspring.

The arrangement of the determinants by which bodily characters are affected is caused by architectural peculiarities inherent in the original ovum and spermatozoon. There is contained within each fecundated ovum an

entirely closed system of interrelated units that can only develop in a predetermined manner. We have here a reappearance, under a new form, of the theory of preformation sustained by Haller and combated by Wolff.

Closely connected with this is His's theory of germinal foci (1874), which supposes that within the protoplasm of the egg the different parts of the adult body are prelocalized and distinct, although not yet formed. To this view many eminent anatomists and embryologists have adhered, but recent experiments of Hertwig, which show that when the segments of a dividing ovum are shaken apart each may develop into a complete individual, appear to have dissipated these ingeniously devised theories as a puff of wind lays prostrate a house of cards.

Among the most ardent and indefatigable investigators in the domain of general anatomy during the nineteenth century should be mentioned Jacob Henle (1809-1885), professor at Zurich, Heidelberg, and finally at Göttingen. He was among the first to realize the importance of the cell theory and did much toward its establishment. He also advanced what may be called the modern theory of pathological processes, holding that they are merely modifications of those of health.

Albert von Kölliker (born 1817), professor at Zurich and Würzburg, still living full of years and honors, has also had great influence upon research both in general anatomy and embryology.

In comparative anatomy should be mentioned Richard Owen (1804-1892), the author of a curious theory of the vertebral origin of the skeleton, and Thomas H. Huxley (1825-1895), who by his writings and researches greatly furthered the doctrine of development by descent, and Carl Gegenbaur (born 1826), at Heidelberg, whose researches upon the morphology of the head and limbs are justly famous. In the palæontological field great advances have been made by the discovery in America of fossil deposits of great extent, and of importance far surpassing anything hitherto known. These have been especially investigated by Joseph Leidy (1823-1891), professor in the University of Pennsylvania; by O. C. Marsh (1831-1899), professor in Yale University; Edward D. Cope (1840-1897), professor in the University of Pennsylvania; Henry F. Osborn (born 1857), professor in Columbia University; and G. Baur, professor in the University of Chicago. They have thrown great light upon human anatomy by confirming in a striking degree the theories of development and the morphological laws controlling the formation of the human body. The anatomy of the head, of the teeth, and of the vertebral column have been especially elucidated.

The advancement of embryology has been greatly aided by the anatomists whose names have been already given, and also by Johannes Müller (1801-1858), professor at Bonn and Berlin, one of the most learned men of his day, who especially studied the development of the genital organs, the glands, and the peritoneum, and by Francis M. Balfour (1851-1882), professor at Cambridge, whose tragic death on the Aiguille Blanche of the Alps was a great loss to science. An important advance in the establishment of the phyletic history of man and other animals was made in 1874 by Ernst Haeckel (born 1834), professor at Jena, who attempted to show that all animals possessing a food sac or intestinal cavity are descended from a common ancestor (as yet hypothetical), the *Gastræa*, and that this is represented in embryological development by a stage which may be termed the gastrula, formed by the invagination of the blastodermic vesicle or blastula. This, the celebrated *gastræa theory*, aroused violent opposition from the opponents of the development hypothesis, but is now quite generally accepted.

The details of the intracellular phenomena of the fecundation of the ovum were first observed by Oscar Hertwig in 1875, in the transparent eggs of the sea urchin.

In osteology during the century there should be noted the work of John Goodsir (1814-1867) on the structure and development of bone, the discovery of the lacunæ and canaliculi by Purkinje, and that of the osteoblasts by Gegenbaur (1864). William Sharpey (1802-1880) did much to increase the knowledge of the structure and development of bone, as also did Ollier and Robin in France and H. Müller, Gegenbaur, and Kölliker in Germany. The architecture of the spongy tissue of bones has received especial attention from Jeffries Wyman of Harvard University and from H. von Meyer of Zurich. The development of limbs in vertebrates has been studied by R. Wiedersheim of Freiburg, the form of the skull by R. Virchow of Berlin, and Welcker of Halle, the general morphology of the skull by Götte of Strasburg, and Gegenbaur (1887). The vertebral column has been investigated by Cunningham of Dublin, Merkel and Henke.

Arthrology has made important advances in precision and knowledge of the mechanism of joints. Especially worthy of mention are the works of Meyer of Zurich, Braune of Leipsic, Morris of London, Heiberg of Christiania, and Bigelow and Dwight of Boston. Bland Sutton, of London, has investigated the nature of ligaments, Bernays, of St. Louis, the development of joints.

In myology the minute anatomy of muscle has received particular attention, but cannot yet be said to be settled, as a knowledge of the intimate structure of protoplasm is as yet imperfect. Bowman, in 1840, was the first to throw any clear light on the subject. He was followed by Leydig and Cohnheim. Afterward Krause (1868) brought forward his theory of "muscle caskets," Hensen showed new details, and Merkel, Engelmann, Rollett, and Ranvier respectively advanced their views. The general morphology of the muscular system has been advanced by the researches of Huxley, Humphry of Cambridge, and Gegenbaur; the study of muscular anomalies has been pursued by Wenzel Gruber, Theile, Wood, Macalister, Struthers, Chudzinsky, Testut, and Ledouble. Special groups of muscles have also received attention, Fürbringer studying those of the larynx and of the shoulder, von Bardeleben and Cunningham those of the hand and foot, Ruge those of the face.

In the earlier part of the century the structure of the capillaries was not understood, it being believed that they were interstitial lacunæ without walls. The demonstration of their independence and continuity was first made by Treviranus in 1836. The endothelium of the blood-vessels was first demonstrated by Henle in 1838. Johannes Müller made important discoveries in the vascular system, especially that of the helicine arteries of erectile tissue, in 1835.

The study of the formed elements of the blood has greatly advanced, but still leaves much to be desired. The blood platelets (hæmatoblasts or third corpuscles) were first discovered by Max Schultze in 1865, and were afterward studied by Bizzozero, Hayem, and Pouchet. Ehrlich (1891) carefully studied the white corpuscles and separated them into varieties that appear to be of great value in pathological anatomy. Neumann and Malassez have investigated the origin and formation of the red blood corpuscles.

Other angiological studies of note are those of His and Bernays on the development of the heart, of Braune on the venous system, and of Bardeleben, Thoma and Bonnet on the variations in the structure of the vascular walls. Heubner (1872) greatly elucidated the vascular distribution in the brain. A profound study of vascular anomalies has been made by W. Krause.

The lymphatics, formerly believed to originate from the interstitial spaces of connective tissue (Ludwig, Brücke), were shown by Recklinghausen, Kölliker, and Ranvier to form a closed system. The true nature of the lymphatic glands has been elucidated by the labors of His, Klein, Ranvier, and others. Important investigations into the origin of the lymphatics have been made by P. C. Sappey (1810-1896), professor at Paris, and by Ranvier. The connection of the serous cavities of the body with the lymphatic system has been studied by Schweigger-Seidel, Klein, Tourneux, and Kolossow. The lymphatic tissue of the throat (pharyngeal tonsil, etc.) has been the object of research by Killian, Stöhr, Flesch, and others; and von Davidoff and Klatsch have shown

that the lymphoid tissue of the intestine, the mesenteric glands, and the spleen are all developed from the intestinal epithelium, a conception which Stieda has extended to the thymus gland. Finally Heidenhain has demonstrated the wandering of leucocytes throughout glandular tissues.

The convolutions of the brain were thought by the earlier anatomists to be arranged without definite order, being compared to the irregularities of the coils of the small intestine. In 1855 Gratiolet (1815–1865), by a careful comparative study of the brains of man and animals, showed that the apparently confused complexity can be reduced to a comparatively simple plan. This was further developed by Pozzi, Leuret, Ecker, Giacomini, and others.

Closely connected with this is the discovery, first made by Broca, that certain motor and sensory activities can be located in definite areas of the cerebral cortex. He noted that the loss of articulate speech known as aphasia is usually associated with a lesion of the left third frontal convolution (Broca's convolution). This doctrine has been greatly expanded by the experiments of Fritsch and Hitzig, Ferrier, Charcot, Horseley, and many others, and has become of great diagnostic value. It will be perceived that it only superficially resembles the older doctrine of Gall and Spurzheim.

The nerve cells in the brain and spinal cord were probably first mentioned in 1833, by Christian Gottfried Ehrenberg (1795–1876), professor at Berlin. They were better described, however, in 1836, both by Gabriel Gustav Valentin (1810–1833), professor at Berne, and Johannes Evangelista Purkinje (1787–1869), professor at Breslau and Prague, from whom are named the cells or corpuscles of Purkinje in the cerebellum. They were for some time misunderstood, Magendie, in 1839, describing them as infusoria. Their nervous character was established in 1844 by Robert Remak (1815–1865), professor at Berlin, who at the same time suggested their connection with nerve fibres.

The first to note the axis cylinder process or axone of nerve cells appears to have been Rudolph Wagner (1805–1864), professor at Göttingen, but its true nature was first shown by Otto F. K. Deiters (1834–1863), professor at Bonn, in 1865. Although unable to demonstrate its actual continuity with the axis cylinder of a nerve fibre, he gave to the process the name by which it is generally known and also named the protoplasmic processes or dendrites. The connection of nerve cells with nerve fibres remained for some time obscure. Counting experiments instituted by Benedict Stilling (1810–1879), of Kassel, showed that at the level of the second cervical nerve there are found not more than half the number of fibres that reach the cord by the posterior nerve roots.

Since the direct methods of anatomical research failed to resolve the complex architecture of the nervous system, recourse was had to the indirect methods of physiological experimentation, pathological lesions, and embryological development. In 1833 Marshall Hall, of London (1790–1857), first clearly demonstrated reflex movements and the independent action of the spinal cord and the medulla oblongata, already surmised by Descartes. As early as 1839 Nasse showed that when a nerve is cut its peripheral end degenerates, and in 1850 this was more carefully studied by Augustus Waller (died 1870), who showed that it is always the end that is detached from the nerve cell that perishes, and that when the posterior root of a spinal nerve is severed between its ganglion and the cord, an area of ascending degeneration will ascend to the cord. In 1852 Ludwig Türck, of Vienna (1810–1868), showed that a descending degeneration might occur from a lesion of the cord. Following these were similar experiments by Burdach, Goll, Charcot, Vulpian, Kahler and Pick, Gowers, and many others, showing the results of lesions of the brain or cord in producing degenerations.

Connected with these are the experiments instituted by Bernhard von Gudden (1824–1886), professor at Munich, which showed that when, in a young animal, a nerve root or nerve tract is torn away or injured, the group of cells with which it is centrally connected suffers atrophy. Among the experimenters in this line of work there may be mentioned Hayem, Forel, and von Monakow.

Many investigators had noticed in sections of the brain and cord a difference in coloration between fetal and adult structures which varied with advancing growth. It was Paul Flechsig, of Leipsic, who first showed that this was due to the fact that different groups of fibres develop their myeline sheath at different epochs, and that by this means certain fibre systems can be made out that correspond in general to the results obtained by degenerations. Improvements in technical methods have made this means of research comparatively easy, and such investigations of the nervous system have been carried on by Bechterew, Edinger, Darkschewitch, and others.

Observations in the comparative anatomy of the nervous system have also led to important results. In this field should be mentioned the names of Theodor Meynert (1833–1892), professor at Vienna; Mathias Duval, professor at Paris; and E. C. Spitzka, professor at New York.

By a combination of these methods there was gradually evolved a general idea of the architecture of the central nervous system. This was, however, necessarily somewhat vague and indefinite as long as the minute anatomical relations could not be actually demonstrated. Power to do this was at last obtained by the improvement in technical methods which made it possible to demonstrate the finest ramifications of the nerve cells. Hence arose the *neurone theory* as advanced by Ramón y Cajal, van Gehuchten, Lenhossék, and supported by Kölliker and Waldeyer. According to Joseph von Gerlach (died 1896), the protoplasmic processes of cells unite in a fine anastomotic network upon which all sensory impressions are discharged and from which, in some mysterious manner, all motor impulses originate. This doctrine was opposed by His (1886) on embryological grounds, by Forel (1887) on pathological grounds. The new methods of staining showed that nerve fibres are merely elongated processes of nerve cells. This led to the conception that the nervous system is composed of histological units (termed neurones by Waldeyer) which may comprise a cell body with its extensions, the protoplasmic processes, the axis-cylinder processes, the nerve fibres, and end organs. These units are held to be substantially independent of each other, never uniting to form a plexus. This view, which has been used with great success to explain the architecture of the nervous system, is now accepted by most histologists. It should be noted, however, that the recent investigations of Apáthy (1897) on the earthworm and leech seem to show that it may require some modification.

The internal structure of the body of the nerve cell has also received much attention and is still under discussion. Remak and Max Schultze considered it fibrillary with interstitial granules. Franz Nissl, by peculiar methods of staining, thinks that he has shown that the structure is not fibrillary, but that two substances exist, one being masses of stainable granular substance (Nissl bodies, tigroid substance), the other unstainable. He considers that different types of cells exist distinguishable by the arrangement of these substances.

The finer anatomy of the organs of special sense is almost wholly the work of the nineteenth century. The development of the eye has been most carefully investigated by Hatschek, Ayers (of Cincinnati), and Kupffer, and the curious discovery was made by Ahlborn (1886), Rabl-Ruckhard, and Spencer that the pineal body is a vestige of an eye that occurs in some reptiles. The anterior limiting layer of the cornea was discovered by Sir William Bowman (1816–1892), professor at London; the scleral sinus (canal of Schlemm) was first described by Schlemm (1830), but was previously known to Albinus, as appears from a catalogue of his preparations. The ciliary muscle was first demonstrated as such (in the sheep) by William Clay Wallace, of New York (1835). Brücke (1846) and Bowman (1847) afterward described it. Even the deep circular fibres whose discovery is usually ascribed to H. Müller appear to have been seen

by Wallace. The action of the muscle was first correctly described by Helmholtz (1851). A controversy of long standing regarding the existence of a dilatator muscle of the iris appears to have been settled affirmatively by the researches of Kölliker, Retzius, and Juler. The structure of the lids, the lachrymal apparatus, and the retina was specially studied by H. Müller (Müller's muscle, Müller's fibres). The layer of rods and cones (Jacob's membrane) was discovered by A. Jacob, of Dublin, in 1819, the visual purple by Boll in 1876. Recently important comparative studies of the retina have been made by W. Krause and Ramón y Cajal.

The complicated anatomy of the ear has been the object of research by a great number of observers, only a few of whom can be mentioned here. The membrana tympani has been carefully investigated by O. Shrapnell (1832), Jos. Toynbee (1851), Rüdinger (1867), and Prussak (1868); the anatomy of the auditory ossicles and the mechanism of their movements has been elucidated by Helmholtz (1868); the Eustachian tube has been specially studied by Rüdinger, Huschke, and Kölliker; the membranous labyrinth by Böttcher, Henle, and Hyrtl. The organ of Corti was discovered by the Marchese di Corti in 1851. Additional details of its structure were established by E. Reissner (1854), M. Claudius (1856), O. Deiters (1860), and Hensen (1863). Special memoirs on the anatomy of the ear have been written by Rüdinger, Wharton Jones, Ayers, and Retzius.

As to the organ of smell, the olfactory cells were first described by Max Schultze in 1862, although they were probably seen previously by Ecker and Eckhardt. The tracing of the olfactory fibres has been effected by the labors of Kölliker, van Gehuchten, and Ramón y Cajal. The general anatomy of the passages of the nose has been carefully studied by Zuckerkandl.

The taste buds of the tongue were discovered by Schwalbe, of Strasburg, in 1867, and at about the same time by Lovén, of Christiania.

The tactile corpuscles of the skin were first seen by Meissner and Wagner in 1852, the end bulbs by W. Krause and Kölliker (1850–1858). Pacini discovered the corpuscles that bear his name in 1836, and they were described by Vater somewhat later (1841). Other nerve endings recently described are those of Golgi in tendons (1878), those of Ruffini in the fingers (1893), and the "muscle spindles" of Kühne and others found in the substance of muscle.

Most of our accurate knowledge of the minute anatomy of the viscera has been developed during the present century. Space does not permit a detailed account of the discoveries, but mention should be made of the work of Neumann, Lent, and Röse upon the teeth, and the attempts of Ryder, Osborn, Cope, and others to obtain from palæontological and other evidence a connected account of the mechanics of their development; of the work of Flemming, of Kiel, upon the principles of gland construction; and that of Heidenhain of Breslau upon the anatomy of the pancreas, the salivary and peptic glands. Investigations of the development of the peritoneum by Toldt, His, Treves, Brösike, and others have greatly aided our comprehension of that complicated structure. The liver has been specially investigated by Kiernan, Hering, Heidenhain, and Ranvier, and in the anatomy of the kidney great advances have been made. Henle described the loops of the uriniferous tubules that bear his name in 1862, Ludwig and Heidenhain have done much in elucidating the structure of the tubules, and Disse has studied the changes of the epithelia during secretion.

In the generative organs of the male researches in spermatogenesis have been carried on by La Valette St. George, Nussbaum, Flemming, Hermann, and Minot. In the female organs Pflüger and Waldeyer have investigated the structure of the ovary and the development of ovules, and Nagel has given the first exact description of the human ovum. The situation of the pelvic organs has been carefully determined by B. Schultze and Waldeyer, and an exhaustive examination of the human placenta has been made by Minot. *Frank Baker.*

ANCHYLODYNIA. See *Foot* (*Surgical*).

ANCHYLOSIS. See *Ankylosis.*

ANCHYLOSTOMA DUODENALE. See *Nematodes.*

ANDERSON MINERAL SPRINGS.—Lake County, California.

LOCATION.—Nineteen miles from Calistoga, five miles from Middletown, and ten miles from the Great Geysers.

ACCESS.—By stage from Calistoga and Cloverdale.

The worshipper at nature's shrine, the lover of grand and varied scenery, will find all that can be desired at the Anderson Mineral Springs. The mountain stage ride is one of the most picturesque in the State. The ever-changing picture of hill and dale, of forest and shrubbery, and of brooks with ferns and mosses forms one of those pleasing panoramas which the spectator loves to recall in after days. The springs with the hotel and cottages are located in a cozy nook in a small cañon surrounded by forests abounding in picturesque waterfalls. The cool, leafy dells and the profound silence and solitude of the dense forests form an ideal combination to attract the early morning rambler. The atmosphere here is balmy and exhilarating and free from humidity. Fish and game abound all the year round. The accommodations offered to guests are excellent, and visitors come by the thousand to enjoy the numerous advantages of the spot. There are nine important springs. The principal drinking-spring, known as the Cold Sulphur, is located about one hundred and fifty yards from the hotel. It was analyzed by Dr. Winslow Anderson and found by him to have the following composition:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	1.09
Sodium carbonate	9.27
Sodium sulphate	6.18
Potassium salts	Traces.
Magnesium carbonate	11.73
Magnesium sulphate	16.95
Calcium carbonate	20.40
Calcium sulphate	9.10
Ferrous carbonate	0.46
Arsenious salts	Traces.
Silica	2.45
Organic matter	Traces.
Total	77.63
	Cub. in.
Gases { Carbonic acid gas	243.50
Gases { Sulphureted hydrogen	4.20

This may be characterized as a saline sulpho-carbonated water. It has been found very beneficial in chronic skin diseases of strumous and syphilitic origin. In liver and bowel troubles, in uterine and ovarian engorgement, and in glandular congestions, the water has also proved to be of much value. It is aperient, diuretic, and alterative in its action.

The "Sour Spring" is one of the few California mineral springs containing free sulphuric acid. Its sour taste is supposed to be due to alum, but the following analysis by Mr. George E. Colby, of the California State University (1889), shows that no alum is present:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.08
Sodium sulphate	0.49
Potassium sulphate	0.87
Magnesium sulphate	4.76
Calcium sulphate	2.07
Ferric sulphate	0.63
Aluminum sulphate *	7.11
Boric acid (with spectroscope)	Strong test.
Lithium (with spectroscope)	Well-marked test.
Ammonia (manganous sulphate)	0.33
Silica	3.94
Organic matter	Traces.
Total	20.28

* A microscopic examination of the residue obtained by slow evaporation fails to show characteristic crystals of alum.

A considerable quantity of free sulphuric acid was also revealed by the analysis. The temperature of the water is 64.3° F. It possesses tonic, astringent, and gently laxative properties, and has proved beneficial in hemorrhages from the lungs, menorrhagia, dyspepsia, etc.

Another valuable water is the "Iron Spring." The following is Mr. Colby's analysis, made in 1899:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.18
Sodium bicarbonate	0.19
Sodium sulphate	3.42
Potassium sulphate	1.17
Magnesium sulphate	7.35
Calcium sulphate	10.88
Calcium phosphate	0.15
Ferrous carbonate	1.18
Alumina	0.93
Boric acid (with spectroscope)	Strong test.
Lithium (with spectroscope)	Well-marked test.
Manganous carbonate	1.77
Silica	4.22
Organic matter	Small quantity.
Total	31.44

Free carbonic acid gas, 25.80 cubic inches.
Temperature of water, 124° F.

This is a mild calcic-chalybeate water. It possesses tonic and slightly laxative properties, and is useful in anæmia and chlorosis and in conditions requiring restorative agents.

Among other valuable springs in this group may be mentioned the "Cosmopolitan," an excellent drinking water, possessing laxative properties; the "Belmar" Spring, a light saline-sulphur water; the "Magnesia Spring" (known also as "Father Joseph's Spring"), a rich saline water having valuable laxative properties; and the "Hot Sulphurous" or bathing spring. These last waters have a temperature of 145.5° F., and have been found very beneficial in rheumatism, chronic joint swellings, and skin diseases. It is claimed that the inhalation of the hot sulphurous steam of this water is highly useful in cases of chronic bronchitis, incipient phthisis, and catarrhal affections of the nose and throat. There are good facilities for bathing. The incrustations formed by the hot sulphurous vapors on the surrounding rocks are gathered and powdered and used in cases of chronic nasal catarrh, as well as for acute coryza and colds in the throat. This powder represents all of the solid mineral ingredients found in the water.

James K. Crook.

ANDROMEDOTOXIN. See *Ericaceæ*.

ANDROPOGON. See *Citronella Grass*.

ANELECTROTONUS. See *Electrotonus*.

ANENCEPHALUS. See *Teratology*.

ANESON.—Anesin; chloretone; acetone-chloroform. $(CH_3)_2COH,CCl_3$, tertiary trichlorbutylalcohol. Potassium hydroxide is slowly added to a mixture of equal weights of acetone and chloroform, and then steam is blown through. The resulting aneson forms a white crystalline mass resembling camphor and having a camphoraceous odor. It is slightly soluble in cold, more so in boiling water, is fairly soluble in strong alcohol, and freely in ether and chloroform. It is decomposed by strong sulphuric acid, but is not affected by weak acids or alkalies.

Aneson or chloretone is antiseptic, locally anæsthetic, and hypnotic. Combining the properties of an antiseptic and an anæsthetic, it promises to be of considerable value in minor surgery. Kossa and Vamossy found it to be slower in its action than cocaine, and somewhat less penetrating; yet it had more anæsthetic power, as a one-per-cent. solution was equivalent to a 2.8-per-cent. solution of cocaine. A lacerated wound or a burn soaked in a weak solution of aneson soon becomes anæsthetic, and permits of incision, suturing, etc., without pain. For other minor operations, especially about the mouth, nose, and eye, or for circumcision, it is superior to cocaine, and is used in such weak solution as not to have any systemic effect. It is non-irritant and does not dilate the pupil, and being a very stable compound its antiseptic power may be increased by the addition of mercuric bichloride, phenol, thymol, etc.

Houghton and also Albrich have found aneson to be readily absorbed from the stomach, and rapidly distributed throughout the body. It tends to slow the heart without weakening it, and it has no effect on the arteries or on the blood. In animals killed after large doses the greater amount of the drug is found in the brain. It is sedative and readily produces hypnosis, but has little or no effect on the important centres in the medulla oblongata. Aneson is not eliminated as such by the kidneys, the skin, or the lungs, and, as the chlorides in the urine are increased during its administration, it is probable that the drug is broken up in the system. Given by mouth, the mucous membrane of the alimentary canal becomes insensitive, nausea and seasickness are relieved, and in gastric cancer or ulcer, the pain and persistent vomiting are overcome. As a hypnotic, it does not irritate the stomach or the kidneys, and may be used with safety in cardiac and respiratory diseases. Five to twenty grains may be given in powder or capsule half an hour before bedtime, as its action is fairly rapid. Sixty grains have been given without disagreeable effect. As an anæsthetic it may be used in one-per-cent. solution, either directly applied to the surface or subcutaneously.

W. A. Bastedo.

ANEURISM.—An aneurism of an artery is a circumscribed tumor composed of a sac, the cavity of which communicates with the lumen of the artery, and contains liquid or coagulated blood. The sac may be formed in whole or in part of the distended wall of the artery, or of the condensed adjoining tissues.

DEFINITIONS AND CLASSIFICATION.—The terminology of the affection has been much confused by a lack of agreement in the use of terms and in the meaning attached to them. Most of these terms are intended to indicate differences in the composition of the wall of the sac, some of which cannot even be recognized with certainty on direct examination, and are not marked by any corresponding clinical differences.

Internal and External.—*Internal* aneurisms are those situated within the thoracic or abdominal cavity; *external* aneurisms are those formed at the expense of arteries lying outside these cavities. (*Medical* is sometimes used as a synonym of internal; *surgical*, of external.)

Spontaneous and Traumatic.—*Spontaneous* aneurisms are those that have arisen in consequence of disease or gradual change in the wall of an artery. A *traumatic* aneurism is one which has formed in consequence of sudden mechanical division or injury of the wall of an artery, as by a knife or splinter of bone.

The following anatomical classification, adopted by Holmes, is the one in common use. The distinction made between "true" and "false" aneurisms is anatomically justified, but the terms are likely to mislead, for "true" aneurisms, in the narrow sense of the term—*i.e.*, aneurisms whose walls are everywhere composed of all the coats of the artery—are rare and always small. The common form of aneurism belongs to the class termed "false," those in which only one of the coats of the artery takes part in the formation of the wall of the sac.

I. Common or encysted aneurism, subdivided into—

(*a*) Aneurismal dilatation, or fusiform aneurism. The artery is dilated for some distance, and the wall of the dilated portion preserves its three coats.

(*b*) True aneurism. The sac is formed throughout by all the coats of the artery dilated at only one point.

(*c*) False aneurism. The sac is formed by only one or two of the coats of the artery, the middle one having disappeared or being unrecognizable in consequence of change.

(*d*) Consecutive or diffused aneurism. The wall of the sac is formed of the condensed adjoining tissues, and the communication of its cavity with the artery is therefore through an actual opening in the wall of the latter. A traumatic aneurism is the type of this class, but most, if not all, large aneurisms would be included under the definition, rather than in class (*c*), because of the substitution of condensed connective tissue in the wall for the distended external coat of the artery. The presence of a lining coat similar to the intima of the artery is not proof of the persistence of the latter; it may be of new formation.

II. Arterio-venous aneurism, formed by abnormal communication between an artery and a vein; subdivided into—

(*a*) Aneurismal varix, in which there is no sac intermediate between the artery and the vein; and

(*b*) Varicose aneurism, in which there is an intermediate sac.

III. Cirsoid aneurism (or arterial varix), formed by the general dilatation of an artery and its branches.

IV. Dissecting aneurism, formed by the effusion of blood between the coats of an artery after ulceration of the intima.

I. Common Encysted Aneurism (mainly Spontaneous).—The formation of a spontaneous aneurism appears to be preceded by a degenerative change in the wall of the artery by which both its elasticity and its power to resist a distending strain are diminished. This change is in the nature of an endarteritis and mesarteritis, and consists in a hyaline degeneration of the intima and a disintegration of the elastic and muscular tissues forming the middle coat. It may begin without known cause, or may follow the lodgment of an embolus or some mechanical injury to the vessel, as the overstretching of the artery, the application of a ligature,* or even, as in one case, prolonged digital pressure. Under the influence of the blood pressure, increased at every contraction of the heart, the degenerated wall yields, and becomes stretched; if the degeneration has involved the entire circumference and a considerable length of the vessel, the dilatation is uniform (fusiform aneurism) or irregularly pouched; if only a small portion of the wall is involved, it expands and forms a pouch which communicates, either largely or by a narrow opening, with the lumen of the artery. The elongated forms, or dilatations, are common in the aorta, the pouched forms in the arteries of the limbs. In small, bud-like aneurisms the persisting three coats can be identified; in the larger ones they cannot be traced for more than a very short distance beyond the neck of the sac. It is reported that Haller produced aneurisms in frogs by dissecting away the outer coat of the artery (the mesenteric), but similar attempts made by Hunter upon the carotid and femoral of the dog were unsuccessful, although the dissection was carried so far that the color of the blood could be seen through the thin remaining portion of the wall.[1] The effect of local inflammatory conditions in producing aneurism is best seen in the small ones due to infected emboli coming from the heart in endocarditis, and in those due to the extension to the vessel of tuberculous processes on the outside; in these it appears that dissociation of the elastic bundles of the media is a necessary preliminary.

Examination of the wall of a sacculated aneurism of considerable size (Fig. 198) shows that it is composed of condensed connective tissue, with a lining membrane in its inner surface that resembles the intima of an artery to this extent, that it has an epithelial surface of flat cells and a deeper structure of flat cells separated by a fibrillary substance. A similar structure is found also upon the surface of thrombi, as after the ligature of an artery, and it must, therefore, be deemed not simply a distended intima, but rather a layer of newly formed tissue. Traces of the middle coat may be found at different parts of the aneurismal sac, especially in the neighborhood of its neck, where, indeed, they may form a continuous layer with that of the artery; but in the more distended portions of the sac they are entirely absent, and it appears to be well established that there is no hyperplasia of the muscular and elastic tissues which compose this coat, but that their elements undergo not only degeneration but also mechanical separation, and they have practically no share in the formation of the wall.

Fig. 198.—Aneurism of the Femoral Artery. The walls of the sac consist only of the *adventitia* (*a*) and *intima* (*b*); the *muscularis* (*c*) remains only at the entrance of the sac. (Weber.)

The new tissue may itself either undergo fatty degeneration, or become atheromatous or calcified. As the sac enlarges it may become thinned at some point and burst, with escape of its contents into the adjoining tissues ("ruptured aneurism"); and when, in its growth, it reaches and presses upon firm, unyielding tissues, like bone, the latter undergo absorption. Bone disappears under this pressure by rarefaction; that is, a general rarefying osteitis is set up, characterized by the enlargement of the vascular canals of the bone, by multiplication of the cellular elements, and by disappearance of the earthy salts, but without production of pus. Other tissues may become inflamed under the same irritation, and the inflammation may be plastic, with production of adhesions, or ulcerative. Thus, adjoining serous surfaces unite (pleura, pericardium, peritoneum), or rupture may take place through ulceration of the walls of the trachea or of the œsophagus, or of the wall of any other cavity that is pressed upon. These openings may be large or small, and may give rise to repeated small hemorrhages, or may cause death instantly by a free one, either external or internal.

The growth of the sac takes place in the direction of least resistance, but this direction is determined rather by the distensibility of the wall itself than by the resistance of the surrounding parts. Thus, the wall may be comparatively firm on the side adjoining a cavity, and growth may be slow in that direction, while at another point where it rests against bone the latter may be rapidly absorbed and even perforated, as is seen in the sternum, and this perforation will be followed by rapid enlargement of the aneurism through the opening. Aneurisms of the limbs seldom rupture through the overlying skin, probably because they receive treatment before their growth has reached such a point; but those of the thoracic aorta and innominate not infrequently end by ulceration of the skin and fatal external hemorrhage. An aortic aneurism reaches the surface either by growth upward into the neck or through the sternum, or between the ribs to the surface of the chest. The absorption of the bodies of the vertebræ by thoracic or abdominal aneurisms gives rise to some of the most painful symptoms of this fatal and painful affection. In two cases quoted by Mr. Holmes from Dr. Gairdner the spontaneous opening of an aneurism through the skin was followed by the healing of the opening, and in one of them apparently by the cure of the disease; but such a result is so entirely exceptional that it deserves mention only as a surgical curiosity. When an aneurism has ruptured externally or internally, the progress, in the immense majority of cases, is from bad to worse if the hemorrhage is not immediately fatal. The bleeding may be arrested by syncope or by the plugging of the orifice

* See cases quoted by Follin ("Pathologie Externe," vol. ii., p. 389), in one of which three aneurisms formed after three successive ligatures, of which the first was in an amputation just above the elbow, the second of the brachial, to cure the first; the third, to cure the second; a fourth ligature, on the axillary artery, was not followed by dilatation. The case was Warner's, in the first half of the eighteenth century, and the aneurism was laid open in each operation.

by a clot, but it recurs again and again, and ultimately proves fatal, unless the recurrence can be prevented by treatment.

The pressure of the growing tumor not only leads to the condensation and absorption of the tissues pressed upon, but it also causes much pain, either by stretching nerves or by provoking a neuritis, and it may interfere with the circulation of a part or limb by closing a vein or even an artery, and thus lead to gangrene.

The blood contained within an aneurism is usually in part liquid and in part clotted, and the inner surface of the wall of the sac is lined with layers of grayish, opaque fibrin of irregular thickness and extent. These layers may be comparatively thin, or they may fill the greater part of the cavity. They are produced by gradual deposit of the fibrin on the wall, so that those layers that are nearest the wall are the oldest, and also the shortest, because the sac has usually increased in size since they were deposited. They occasionally undergo degeneration and break down into a granular detritus, forming small cavities filled with a pulpy mass. Ordinarily the connection between the wall of the sac and the adjoining layers of fibrin is one merely by contact, and there is no growth of tissue from the former into the latter. This seems to be true at least of all growing aneurisms, but in those that have undergone spontaneous cure, or have been cured by treatment, the development of new tissue is observed. This firm, laminated fibrin is called the "active clot"; the soft, dark clot, or "passive clot," which is frequently found loose in the cavity of the sac, is probably a post-mortem formation in most cases.

The growth of an aneurism may be stayed, and a practical cure obtained, by the deposit of sufficient laminated fibrin either to fill its cavity or thoroughly to protect its wall from the distending effect of the blood pressure, and this is thought to be the mode of cure by most methods of treatment. It seems extremely improbable that this laminated fibrin is a later stage of a "passive" clot; there is every reason to believe that it is gradually deposited as such by the blood in consequence of changes or peculiar conditions in the lining membrane of the sac, or in the rapidity of the circulation. Under ordinary conditions this deposition does not take place rapidly enough to effect a cure; it occurs at some parts of the sac and not at others; its union with the sac is slight, and the blood can readily insinuate itself between the two at the edge of the layers, and as the sac enlarges fresh portions are created and left uncovered to undergo subsequent distention. If the conditions are modified by operative or other treatment that diminishes the volume and force of the stream of blood, time may be given to the tissues of the sac at the edge of the clot to become more intimately adherent to the latter, and thus to make the clot a permanent protection against further increase. This is effected by granulations from the lining membrane, which spread into the clot and over its surface, making it, as it were, a part of the wall of the sac, binding down its edges, and covering it with a smooth epithelial layer. The union between the walls and the layers of fibrin appears to be very slight, and limited to those layers immediately adjoining the wall, and there is no evidence that new vessels extend from the wall or between the layers of the fibrinous clot. Some aneurisms, after a long period of rest and apparent cure, have begun again to pulsate and to enlarge, and this fact can be explained only on the theory of a simple mechanical obstruction that has persisted during the period of quiescence, and has then yielded and allowed the re-entrance of blood, the insinuation of blood between the layers of fibrin and the wall.

A cure may also follow the sudden formation of a soft "passive" clot. This fact has only recently been demonstrated by examinations made after the rapid cure of aneurisms by the use of the elastic bandage. The first case is reported by Mr. Wagstaffe in the Transactions of the London Pathological Society, vol. xxix., p. 72; it was a case of popliteal aneurism cured a few months before the patient's death. At the autopsy the sac was found to measure two inches in length and one inch in diameter, and to contain a central blood clot measuring one by one-half inch, and surrounded by fibrous tissue which was continuous with the sac and artery. This tissue was abundantly supplied with blood-vessels, and the artery was permanently closed above and below. The process I conceive to be as follows: In consequence of the arrest of the current of blood, whether by a distal plug, or by ligature, or by compression, the blood within the sac clots, and it probably does so more promptly than within normal vessels because of the character of the inner surface of the wall of the sac. This clot fills the sac, and probably extends for a variable distance into the artery above and below the opening. This extension prevents the re-entrance of blood into the sac even if the obstruction that led to the formation of the clot is afterward removed, and the latter then undergoes those changes with which we are familiar in clots formed outside the body. It divides into two portions. a central, shrunken, firm clot, composed of corpuscles and fibrin, and an external layer of serum. The latter is absorbed by the neighboring tissues, and the sac correspondingly retracts, and its wall thickens by this retraction and possibly by a hyperplasia of its cellular elements, provoked by the irritation excited by the clot. This irritation involves also the adjoining wall of the artery, as is proved by the changes that occur even in normal vessels into which clots have extended. The intima thickens and sends out cellular prolongations, which perforate the clot and spread over its surface; these new cells soon constitute a completely formed and resistant plug structurally continuous with the wall of the artery, and provided with a smooth epithelial surface. The artery is now as completely and permanently closed on each side of the aneurism as if ligatures had been placed upon it there, and the clot is left free to undergo its natural retrogressive changes, and the aneurism is relieved from the distending pressure of the arterial stream. Complete absorption of the serum reduces the clot to less than half its original size, and this reduction is slowly carried further by molecular disintegration and absorption of the corpuscles and fibrin.

FIG. 199. — Section of an Aneurismal Sac Containing a Clot Surrounded by Organized Fibrous Tissue. (Wagstaffe.)

This conception of the process is supported by our knowledge of the changes which occur in blood that has clotted within the body under other circumstances, by certain clinical features observed in aneurisms that are undergoing or have undergone cure, and by the examination of specimens. Thus, in a case of popliteal aneurism cured by the application of the rubber bandage, a non-pulsating area of fluctuation appeared in the sac a day or two after the operation, and slowly disappeared as the tumor diminished; there can be but little doubt that it was due to the pressure of serum exuded from the clot more rapidly than it was absorbed by the surrounding tissues. Again, in Mr. Wagstaffe's case above referred to, there was found a central blood clot of comparatively small size, closely surrounded by the thickened sac, and the artery was permanently occluded by fibrous tissue continuous with its wall and with that of the sac; and in Dr. Reid's case (*Lancet*, August 5, 1876), the first one cured by the use of the elastic bandage, a similar condition of the parts was found: a central blood clot, dark in color and of cheesy consistency; a contracted but thin sac with a few partly adherent layers of laminated fibrin; and the artery occluded by fibrous tissue for a distance of two and one-half inches above the sac.

The transformation of an obliterated aneurism into a blood cyst after many years has been observed in one

case, which is apparently unique. It is reported by Reinhold ("Inaug. Dissert.," Marburg, 1882; abstract in *Centralblatt für Chirurgie*, 1882, p. 571). It was a traumatic varicose aneurism of the popliteal artery and vein successfully treated by ligature of the femoral artery and by compression of the sac. Nine years afterward a large, tense cyst formed, containing crystals of cholesterin and hæmatin, and suppurated after multiple punctures; it was then laid open, and several old blood clots and a few calcified fragments were turned out.

Causes.—Anything which reduces the power of resistance possessed by the arterial wall below what is sufficient effectively to oppose the distending force of the blood may be an immediate or a predisposing cause of aneurism. A sudden increase of intravascular pressure may combine with pre-existing weakness of the wall to produce an aneurism, but in the great majority of cases the change which leads to this production lies in the wall alone. Mr. Holmes quotes two cases in which the formation of an abdominal aneurism appeared to have been the direct consequence of the emotion experienced by a criminal on receiving a severe sentence. Weakness of the wall may be limited to a single large or small area, or may exist at many points, with the production of a corresponding number of aneurisms. This latter condition is termed the *aneurismal diathesis*, and although the affection is usually single, as many as sixty-three aneurisms have been found in one individual. The weakness of the wall is the result of change in the inner, and especially the middle, coats of the artery, and this change may be either the hyaline degeneration above described, or the one known as atheroma. Among the predisposing causes, therefore, must be counted all those which lead to degeneration of the arterial wall. The statistics collected by Mr. Crisp show that of 551 spontaneous aneurisms of all kinds, only 2 were of the pulmonary artery, 175 of the thoracic aorta, 59 of the abdominal aorta, 137 of the popliteal artery, 66 of the femoral, 24 of the carotid, 23 of the subclavian, 20 of the innominate, and 18 of the axillary. The disease is most common between the ages of thirty and fifty years, and is very rare in childhood; cases have been operated upon at eight and nine years. Broca claimed that the liability to aneurism increased with advancing years in the arteries above the diaphragm, and diminished in those below it. Aneurisms of the arteries of the extremities are much less frequent in women than in men, but there appears to be no such difference as regards internal aneurisms. This unequal distribution as regards the artery, the age, and the sex, indicates some of the causes, both general and special. Among the general causes are habits of life and peculiarities of constitution which increase the arterial tension or diminish the strength of the arterial walls; the special ones are anatomical peculiarities and local lesions, changes, and injuries.

The habits of life which act as predisposing causes are excess in the use of alcoholic drinks, and occupations which call for the exertion of much muscular effort. The influence of syphilis has been alleged, but not proven, and the same is true of its mercurial treatment. The gouty or rheumatic diathesis predisposes to it. The influence of muscular effort, so far at least as regards external aneurisms, is shown by the greater prevalence among males than among females, and the greater frequency during the prime of life, notwithstanding the fact that degenerations of the arterial walls are more common in advanced life. Follin quotes in support of the influence of alcohol a remarkable statement made to him by the Dublin surgeon, Colles, to the effect that while the Father Mathew Temperance Societies flourished in Ireland, aneurisms were much less frequently seen than before or since that time.

The anatomical peculiarities which influence the occurrence of an aneurism are changes in the direction of an artery (as the arch of the aorta), normal enlargements of its calibre (as at the upper end of the carotid), bifurcations, and the neighborhood of joints which are habitually and violently extended and flexed (as the knee and hip). The local changes which are to be regarded as exciting causes are the changes already described as occurring in the arterial wall, and other changes or injuries which diminish its power of resistance or break its continuity. Thus the sharp edge of a calcified atheromatous patch may cut through the intima and admit the blood into the rent, with the subsequent formation of a real aneurism, or of the variety known as dissecting aneurism. Or the middle coat may be ruptured by being overstretched, and the part thus weakened will be expanded to form an aneurism; or ulcerative inflammation outside the vessel may weaken, or even perforate its wall, leading, in the former case, to the formation of a typical aneurism, and, in the latter, to the transformation of an abscess into an aneurism. Or, rarely, the process set up by a ligature upon an artery may extend beyond what is needed for the sealing of the vessel; and so weaken the adjoining portion by modifying its middle coat that it yields under the pressure of the blood and expands into an aneurism. Or an embolus may lodge in an artery and lead to the same result by the same process; this seems to be especially probable when the embolus has formed during ulcerative endocarditis, and the explanation is to be found in the septic or virulent qualities then possessed by the embolus. Four cases of this kind were reported by Dr. James F. Goodhart, in the Transactions of the London Pathological Society, 1877, vol. xxviii., p. 98: in three of them the aneurism occupied the middle cerebral artery, or one of its branches; in the others, the posterior cerebral artery.

Symptoms and Progress.—When an aneurism forms suddenly by rupture or perforation of an artery, or in consequence of a violent effort or emotion, its formation is accompanied by sharp pain and the more or less prompt appearance of a tumor, if it is so situated that a tumor is recognizable. But ordinarily the formation is slow, and the patient's attention is first attracted by the presence of a tumor. This is situated in the line of an artery, is not adherent to the skin, is slightly movable, smooth and regular in outline, usually globular or ovoid, soft and compressible, and pulsates synchronously with the heart. If steady pressure is made upon it, its size may be more or less diminished while the pressure is made, but it immediately regains its former volume when the pressure is removed. If it is grasped between the thumb and fingers or between the two hands, the pulsation is found to be expansile, that is, the fingers or hands are pushed apart by it, not simply lifted by it. If the ear is placed upon it a sound is heard corresponding to the pulsation; this is the *aneurismal bruit;* and while it may vary somewhat in character in different cases, it is usually harsh rather than soft or blowing; it may be limited to the time occupied by the pulsation, or may extend over the entire interval from the beginning of one pulsation to that of the next. If pressure is made upon the artery above the tumor, the latter diminishes somewhat in size, and the pulsation and bruit cease. The pulsation in the distal branches of the artery may be normal or diminished; and if the tumor presses upon the corresponding vein, the limb may be œdematous and swollen. The compressibility and softness of the tumor are modified by the amount of laminated fibrin within the sac.

In thoracic and abdominal aneurisms many of these signs are unrecognizable because of the inaccessibility of the tumor to palpation. The objective symptoms of thoracic aneurism are abnormal dulness on percussion over the region occupied by it, an impulse communicated by it to the sternum or ribs, aneurismal bruit, and possibly the presence of a tumor at the root of the neck or on the front of the chest. Other symptoms are pain and those produced by pressure on various adjoining organs: dysphagia, diminished respiratory murmur on one side, alteration of the voice by pressure on the recurrent laryngeal nerve, and perhaps differences in the pulse when the two carotids or the two radials are compared. In abdominal aneurism the size, shape, and peculiarities of the tumor can sometimes be recognized.

Pain may accompany aneurism, when once formed, and is due either to stretching of nerves or to pressure upon, and inflammatory processes excited in them and other adjoining tissues.

The tendency of an aneurism is to increase in size; for the absence from the wall of the sac of a muscular coat, the most efficient agent to withstand the expanding blood pressure, leaves the wall unprovided with any tissue able successfully to oppose this pressure. The growth may be rapid or slow, according to circumstances, chief among which are the size of the opening by which the sac communicates with the artery, the firmness of the surrounding tissues, and the readiness with which the blood in the aneurism clots or deposits laminated fibrin upon its wall. The enlargement may be uniform, or more marked at some points, and may take place more rapidly at certain times than at others.

The natural tendency of an aneurism is to spread and finally to rupture, either by gradual weakening of its wall or by ulceration into a natural adjoining cavity or through the skin. As it approaches the surface the skin becomes tense, adherent, and inflamed, and may ulcerate or become gangrenous. The subcutaneous tissues may be similarly affected, and thus an abscess may form between the sac and the skin, into which the aneurism may rupture either before or after the abscess has opened externally. The inflammatory process outside the sac has been thought to favor coagulation of the blood within it, and thus to lead to a temporary or even a permanent arrest of the disease; but ordinarily free hemorrhage follows the rupture and requires extreme measures for its arrest, if indeed arrest is possible.

The most favorable, and one of the possible terminations of aneurism, is its *spontaneous cure* by coagulation of the blood within it. Some of the conditions which provoke or favor this occurrence have already been referred to. They may all be classified under three heads: (1) Those which favor clotting in the sac by retardation or arrest of the current through it; (2) those which increase the coagulability of the blood; (3) those which provoke coagulation through change in or about the wall of the sac.

(1) *Retardation or arrest of the current;* and (2) *Conditions which increase the coagulability of the blood.* It has been abundantly proved, both clinically and by the study of specimens, that total arrest of the current in the sac is not necessary for the coagulation of the blood contained in it, but that a partial arrest or slowing, effected by influences acting upon the general circulation or only upon the blood occupying portions of the sac, may either begin the process or promote the extension of the process after it has been begun. Most aneurisms of any size contain laminated fibrin adherent to some portion of the wall, and some are found completely filled with it, or so nearly filled as to leave only a small canal through which the current is maintained. When these clots are small, they habitually occupy those portions of the sac in which the circulation was apparently the least rapid, and it has been observed that the adoption of measures or the occurrence of changes which have diminished the rate of flow, or the quantity of blood passed through the vessel upon which the aneurism is situated, has been followed by a gradual cure through the deposition of fibrin. The permanency of such a cure depends upon the maintenance of the reduction in the rate or volume of the blood current, or upon the creation of such relations between the clot and the wall of the sac that the former becomes a permanent part of the latter, and protects all portions of it from the action of the expanding force of the blood. These relations consist in the formation of a membrane by proliferation of the cellular elements of the intima of the artery, and the spread of this membrane over the edges and perhaps over the whole of the exposed surface of the clot, in such a way as to prevent the insinuation of the blood between the clot and the wall, and to give a smooth epithelial surface over which the blood passes without depositing additional fibrin.

The causes of retardation or arrest are various. They may be found in the shape of the sac, in the general condition or habits of the patient, or in special modifications of the flow through the artery itself.

Pouched sacs, or sacs with small necks, are more favorable to the occurrence of clotting than are fusiform dilatations or sacs with large, free openings, because the blood that enters does not immediately leave them, but forms a sort of eddy beside the general stream in which the current is slow or almost nil.

Of the causes arising in the general condition or habits of the patient, the first and most important is continuous rest in bed for weeks or months, combined with a light, non-stimulating diet. Other causes, which may also act by increasing the coagulability of the blood, are bleeding, either large or small and repeated, and the internal use of various drugs, such as digitalis, tartar emetic, veratrum viride, iodide of potassium, acetate of lead, ergot, and the chloride of barium. Cures have followed the use of each of these measures, alone or in combination, but it is not always easy to determine how much credit is to be awarded to the treatment in any one case.

Retardation or arrest of the flow may also be caused by obstruction of the orifice of the sac, if it is small, or of the artery above or below the aneurism. The most common agency in producing this change is the detachment of a fragment of fibrin from the wall of the sac and its lodgment in the neck of the sac, or in the artery below. The latter occurrence is habitually accompanied by severe pain in the limb, and is evidenced by arrest of pulsation in the distal branches of the artery. A cure by this mechanism has been observed a number of times, and it forms the basis of a method of treatment suggested by Sir William Ferguson, in which the forcible detachment of a clot from the wall is sought to be effected. If the detached clot is small, it may lodge on the spur of a bifurcation, and then grow in size by additional deposits of fibrin until it obstructs one or both of the branches, and in such a case retardation precedes complete arrest.

This possibility of the detachment of small clots and their passage into the distal branches of the artery involves the risk of other changes far different from the cure of the aneurism. The arrest of the circulation may lead to gangrene of the lower portion of the limb, total or partial, according to the seat of the obliteration; and if the aneurism is situated upon the arch of the aorta or upon one of the vessels going to the head, the emboli may lodge in the vessels of the brain and cause death promptly. I once saw a surgeon examine a patient with an aneurism of the aorta that had perforated the sternum and formed a large tumor over it. He made pressure upon the tumor and reduced it through the opening; as he did so, the patient was seized with convulsions and became unconscious, and after his death, on the following day, the brain, kidneys, and spleen were found filled with emboli, fragments of the laminated clot that had lined the wall of the projecting tumor.

When there is merely retardation of the current the cure takes place by the gradual deposit of laminated fibrin; and when there is total arrest, it takes place probably by coagulation in mass of all the blood within the sac, and the subsequent shrinking of the clot and sealing of the vessel by the production of fibrous tissue, as has been described above.

Another alleged cause of retardation of the stream is pressure of the tumor upon the proximal portion of the artery, but no cases have been reported in which this mechanism has been demonstrated. Its supposed possibility rests upon theoretical grounds alone, and while it may be admitted as a possibility, there is but little reason to believe it has ever taken place.

(3) *Conditions which provoke coagulation through change in or about the wall of the sac.* Inflammation of the sac, or of the tissues immediately overlying it, is alleged by Broca and others to be a cause of coagulation within it and of consequent cure. Mr. Holmes thinks this has

never been demonstrated, and attributes the cure, in the cases that have been cited in support of the theory, to impaction of a clot. There is no doubt that inflammation about an artery or vein can and does often lead to the formation of a thrombus within the vessel, but the conditions in an aneurismal sac are so different that it is perhaps unjustifiable to argue from a supposed analogy.

The sudden formation of a soft clot within an aneurism may excite inflammation and suppuration of the sac with subsequent rupture. In a few cases this has been followed by a cure; but the cure must be attributed to the obstruction of the vessel, either by the original clot previous to the rupture, or by a secondary clot after the hemorrhage that has followed the rupture.

In like manner, tardy suppuration may follow cure, and after an aneurism has remained quiescent and shrunken, in fact cured, for months or even years, such suppuration may lead to the casting out of the clot in whole or in part.

Changes in laminated fibrin after the cure of an aneurism are slight and gradual, and rarely amount to more than a diminution in size by shrinking; sometimes the fibrin becomes soft, and sometimes lime salts are deposited in it. A unique case of late transformation into a blood cyst has been mentioned above.

Diagnosis.—The typical symptoms of aneurism are the existence of a more or less well-defined tumor that pulsates synchronously with the beat of the heart, has a distinct intermittent bruit, and diminishes in size while pressure is made upon it or upon the proximal portion of the artery from which it arises. But these signs may be variously modified or abolished by the varying conditions that have been described above, or may be undemonstrable because of the position of the tumor, or may be simulated by those of other affections. An additional sign is sometimes found in a difference in the character of the pulse in the distal branches of the artery when compared with that in the branches of the corresponding artery of the other side, a difference that may be recognized by the finger, but much more certainly by the sphygmograph.

The diagnosis of aneurism of the thoracic aorta is made by recognition of an abnormal area of dulness, pulsation, and bruit, perhaps with dysphagia, hoarseness, diminished respiratory murmur on one side, interference with the return venous flow from the neck, pain in the chest, and perhaps differences in the radial or carotid pulse. The differential diagnosis between this aneurism and one of the innominate may be difficult or impossible, for an aneurism of the arch of the aorta frequently presents itself as a tumor in the neck, and may even extend into the posterior cervical triangle.

In abdominal aneurism of the aorta, cœliac axis, or mesenteric arteries, the only symptoms may be the indefinite ones of pain and pulsation, with an ill-defined tumor, and it may be impossible to determine whether the tumor itself pulsates or whether the pulsation is not merely communicated to it by the underlying aorta. If it can be grasped and lifted up, the diagnosis can be made, for in such case the pulsation will persist if it is an aneurism, and will cease if it is not. This exploration is not devoid of danger, since the handling may cause the sac to burst, as in a case in which the patient, himself a physician, sought to prove to the attendants that the tumor was a mass of hardened fæces which could be lifted away from the aorta; these gentlemen retired to an adjoining room for consultation, and on their return found the patient dying. The sac had been ruptured.

The symptoms in external aneurism may be modified by the partial or complete consolidation of its contents, or by the temporary obstruction of its orifice, either of which occurrences may greatly diminish or arrest the pulsation and bruit.

The affections with which an aneurism is most likely to be confounded are solid or liquid tumors overlying an artery and very vascular tumors lying in or near the course of a large artery. In all, the common signs are a pulsating tumor with bruit, and the circumstance that the pulsation and bruit may be arrested by pressure on the artery. The pulsation of an aneurism is *expansive*, the tumor enlarging laterally at each pulsation; that of an overlying tumor is a simple lifting of the entire mass; but this difference cannot always be recognized with certainty, for if the fingers cannot be pressed down to the widest part of the tumor, the simple rising of the sloping sides of the globular mass between them forces them apart and simulates lateral expansion. A bruit may be caused in an artery or vein by pressure upon it. In a vein such a bruit is harsh and continuous; in an artery it is intermittent and more "blowing" in character than that of an aneurism.

In the case of a suspected liquid collection simulating aneurism, the diagnosis may be aided by aspiration with a fine needle. An aneurism has been mistaken for an abscess frequently enough to make great caution necessary in the diagnosis and treatment of any supposed abscess lying in the course of a large artery. The fingers should always be pressed deeply into the swelling in search of pulsation, and even if an abscess is certainly present, it should be remembered that it may have formed over an aneurism.

As pulsation and bruit have their origin in the stream of blood brought by the artery, pressure upon the proximal portion of the vessel will arrest them, whether they belong to an aneurism or are simply communicated through a tumor. Vascular tumors, especially those arising from bone, often have well-marked pulsation and bruit; but their pulsation is less "heaving" or "massive" than in aneurism, and the bruit is rarely well marked. The diagnosis may be extremely difficult, or only possible by the aid of exceptional explorations. In a case of large pulsating tumor of the gluteal region, under the care of Prof. Henry B. Sands, in the Roosevelt Hospital, New York, in 1880, the diagnosis of aneurism was made by passing the hand into the rectum, and thus learning that the internal iliac artery was enlarged, the enlargement increasing from above downward to the sacro-sciatic notch. The frequent presence, in vascular tumors, of large collections of blood contained within sacs formed by the rupture or dilatation of capillaries or small vessels, increases the resemblance to an aneurism.

An aneurism which has just ruptured into the adjoining tissues does not pulsate, and may have no bruit; under such circumstances the diagnosis must be made by the history of the case, the pre-existence of a pulsating tumor, and the cessation of the pulsation coincidently with a marked change in the shape and size of the tumor. In like manner, where an artery has just been ruptured or perforated and the blood has been effused into the adjoining tissues, pulsation and bruit are not present until after the effusion has become circumscribed by a distinct firm wall composed of the condensed tissues ("traumatic aneurism" or "ruptured artery").

For the differential diagnosis of arterio-venous aneurism and cirsoid aneurism or arterial varix, *vide infra*.

Prognosis.—The gravity of the prognosis varies with the artery involved, and the size and character of the aneurism. In internal aneurisms the prognosis is very grave; in external aneurisms it is commonly much less so, since in most of them suitable treatment offers a reasonable hope of cure.

Treatment.—Medical treatment.—The medical treatment of aneurism, especially of internal aneurisms, which are commonly regarded, and with much reason, as practically incurable, consists in absolute rest in the recumbent position, maintained for weeks or months, combined with a restricted diet, and aided, perhaps, by the use of various drugs. The absolute rest and the low diet are unquestionably the most efficient part of the treatment, and the drugs, even those for which most has been claimed, are only adjuvants of uncertain and often very doubtful utility. Systematic treatment of this kind dates from the time of Valsalva, and even in his hands the rest was subordinate to repeated venesection, which he carried to

such an extent that rest in bed was a matter not of choice, but of necessity. This active depletion was never regarded with much favor, and as it was long deemed an essential part of treatment by rest, the latter shared in the disfavor of its associate, and patients affected with internal aneurisms were habitually looked upon as beyond the reach of art, and the interference of the physician was restricted to relief of pain and the occasional employment of drugs from which it was thought some benefit might possibly accrue. To Mr. Tufnell,[2] of Dublin, belongs the credit of demonstrating the value of absolute rest in bed and restricted diet in promoting a cure or affording great relief. He insists upon the absolute maintenance of the recumbent posture, and restricts the amount of food to about eight ounces of solid food and six ounces of liquid daily, the solid food being bread, butter, and meat, the liquid milk and a little claret wine.

Of drugs, the iodide of potassium has been most employed, in doses of from half an ounce to one ounce daily. A number of cases of aortic aneurism apparently cured or greatly relieved by its use have been reported.

Digitalis, veratrum viride, and ergot have also been used, with the object of slowing the circulation; occasional supposed cures or temporary arrests by their agency have been reported, but they are not regarded with favor by the authors of systematic treatises on the subject. Ergot is given internally in the form of the fluid extract, or subcutaneously as ergotine. Mr. Holmes regards the acetate of lead as offering the best promise. Dr. F. Flint[3] reported a case of aneurism of the abdominal aorta apparently cured by the use of the chloride of barium in doses of from one-fifth to three-fifths of a grain three times daily for about five months, after Tufnell's method had entirely failed. The most rapid improvement coincided with the smallest dose.

Surgical methods of treatment may be grouped in three classes:

1. Radical obliteration of the sac by opening it and tying the artery immediately above and below its point of communication with the aneurism. This is known as the "old method," or the "method of Antyllus." Under the same head may be included the new method of extirpation of the sac, with ligature of the artery above and below.

2. Permanent or temporary arrest of the afferent stream at a point on the proximal side somewhat removed from the aneurism.

(*a*) Ligature of the artery (Anel's method, or the Hunterian method).

(*b*) Compression of the artery—direct, indirect, digital.

(*c*) Esmarch's elastic bandage.

(*d*) Flexion of the limb.

3. Permanent arrest or obstruction of the stream on the distal side.

(*a*) Distal ligature.

(*b*) Manipulation to produce an embolus or impacted clot.

4. Rapid coagulation of the blood in the sac (with or without temporary arrest of the stream).

(*a*) Coagulating injections.

(*b*) Introduction of solid bodies.

(*c*) Galvano-puncture.

5. Promotion of the formation of a laminated clot by irritation of the wall—"needling."

1. The "old method" (or the method of Antyllus). The aneurisms with which the ancient surgeons had mainly to deal, or at least those to which operative interference was mainly limited, were traumatic aneurisms at the bend of the elbow following venesection. It has been claimed for them that they knew and practised the method of cure by ligature of the artery in continuity above the sac, but Hodgson's statement, which is quoted by Mr. Holmes in support of this claim, does not fully and accurately present the practice. Ligature of the brachial artery "three or four finger-breadths below the axilla" was indeed recommended by Aëtius in the fifth century, but only as a preliminary to the opening of the sac at the elbow and the application of another ligature there, and solely with the object of preventing hemorrhage during the operation proper. The main object of treatment was to remove the clot, which was thought to be a source of danger, and to prevent subsequent hemorrhage by obliterating the artery or closing the opening by which it communicated with the sac. The operation appears to have fallen into disuse and not to have been revived until about the seventeenth century, when it was again used with various modifications, but at first only in traumatic aneurisms at the elbow. It appears to have been first used in popliteal aneurism by Keyslère; the date of his first operation is not known, his second and third were done in 1747 and 1748 respectively. His first three cases were successful; the fourth died.

The method of operation, as practised in popliteal and brachial aneurisms until the end of the eighteenth century, was to control the artery by a tourniquet or the fingers, divide the sac by a longitudinal incision, turn out the clots, find the point of communication with the artery, isolate the latter, and tie it above and below the opening. The cavity was then packed with lint and allowed to fill by granulation.

The difficulties and the dangers were great. The opening into the artery was often deeply placed and difficult of access, so that the external incision needed to be very long (ten inches in a case of popliteal aneurism), and after the opening had been found the isolation of the artery was difficult; it was recommended to seek for it with a catheter or probe, and, after having found it, to introduce this instrument into it and use it as a guide and help in denudation, a suggestion that has recently been revived and practised in similar cases.

The results in popliteal aneurism were so bad that most surgeons appear to have preferred amputation. Pott says he had tried it more than once or twice himself, and had seen it tried by others, but always with a fatal result; and, as Mr. Holmes points out, the immediate acceptance and substitution of the Hunterian operation, which was itself nearly as fatal as amputation of the thigh, shows that the mortality after the old operation must have been frightful. Secondary hemorrhage on the fall of the ligatures was frequent, and so, too, was gangrene of the distal portion of the limb, probably because of the pressure of the lint with which the cavity was stuffed, or of injury to the vein, or of its inclusion in the ligature.

The causes of the bad results are not far to seek: difficult and deep dissection, a large wound, imperfect hæmostasis during the operation, the ligature placed upon an unhealthy portion of the artery, and officious and dangerous modes of dressing make a group of hostile conditions so numerous and powerful that it is not strange so few escaped with their lives. Modern improvements in operative methods, anæsthetics, the catgut or antiseptic ligature, and antiseptic dressings have brought a much larger measure of success in cases even less promising than the average, and the "old method" is still in use and gives fairly good results in cases in which the Hunterian method is impracticable, and, indeed, it even receives the preference in some others. Syme, after a long experience, which included some of the most brilliant and successful operations upon arteries recorded in the history of surgery, formally declared his preference for the old method over the Hunterian, except for aneurisms of the popliteal, femoral, and carotid arteries. The cases in which it has recently been used with success, and for which it is formally recommended[4] after lesser measures have failed, are some traumatic aneurisms, aneurisms of the subclavian, axillary, and gluteal arteries, also after rupture of the sac, as a means of avoiding amputation (Holmes), when the diagnosis is uncertain and the tumor may be cancerous, and when the aneurism has recurred after apparent cure by ligature.

The frequency of secondary hemorrhage was thought by Hunter to be due to the diseased condition of the arterial wall near the sac, where the ligature was applied, and this has always been deemed one of the most weighty

reasons for preferring the Hunterian method, in which the ligature is placed upon a more distant and presumably healthy part of the artery. It must be remembered, however, that secondary hemorrhage was much more common in former days, after all operations in which a large artery was tied, than it is at present, when it has become very rare after ligature with catgut or aseptic silk; and that arteries so degenerated, or even calcified, that they broke when the ligature was drawn tightly, have remained securely closed by slighter pressure, and the wounds have healed without accident. Moreover, recent experience with the catgut ligature in the "old" operation and in extirpation of the sac has shown that the chance of secondary hemorrhage is slight. The objection raised against the old method, that the condition of the adjoining arterial wall is altered, cannot properly be urged in the case of a traumatic aneurism; and the only other possible objections are, that the operation is more difficult and the wound larger.

Syme's method of operating when the artery could not be controlled on the proximal side of the sac was to make an incision into the tumor just large enough to admit his finger, with which he then felt for and compressed the opening in the vessel. If he could not thus find the opening, he enlarged the incision and then introduced a second and a third finger, and, in one case—so says Mr. Holmes—the entire hand. When the opening was found and commanded, he still further enlarged the incision, turned out the clots, and denuded and tied the artery above and below.

Extirpation of the sac is now done as for the removal of a tumor. The mass is exposed by a long incision, the artery is tied above and then below, and the sac is dissected out with great care to avoid injury to the vein.

2. Permanent or temporary arrest of the afferent stream at a point on the proximal side somewhat removed from the sac.

(*a*) Ligature by Anel's method, or the Hunterian method. The question of priority in the introduction of the method of tying the artery above the sac, as now practised, has given rise to much controversy, but must here be dealt with very briefly. It is claimed by the French for Anel, a French surgeon practising in Rome in 1710, and by the English for John Hunter in 1785. The reader who is curious in the matter is referred to Broca ("Des anévrysmes," Paris, 1856) and to Holmes ("A System of Surgery") and to a paper by the writer in the New York *Medical Journal*, November 1, 1884. The facts, in brief, are as follows: January 30, 1710, Anel treated a traumatic aneurism at the bend of the elbow by tying the artery close above the sac without opening the latter, and thereby effected a cure. The patient was a priest. The case gave rise to much discussion, the account of it was reprinted in several books and journals, and the method was subsequently used, before 1785, in at least three other cases, in one of which the ligature was applied about two inches above the sac (Broca, p. 446). June 22, 1785, Desault (after having a few months previously sought to cure an axillary aneurism by compression of the subclavian) treated a popliteal aneurism by tying the artery, "immediately below the ring of the third adductor," that is, at the point where the femoral artery ends and the popliteal artery begins; the aneurism was cured, and the patient died eleven months later of disease of the lower end of the tibia. December 12, 1785, John Hunter treated a popliteal aneurism by tying the femoral artery and vein "rather below the middle of the thigh." * In the following March, 1786, Desault, having knowledge of Hunter's case, operated upon another and tied the artery at a still higher point, dividing the sartorius to expose it.

Hunter repeated the operation four times within the four years following his first case, tying the vein as well as the artery, except in the last two; Desault died shortly after his own second case.

These facts are not disputed: the controversy has arisen over the principles which are thought to have led, in the minds of the different operators (Anel, Desault, and Hunter), to the adoption of the method.

It is claimed by the English (Guthrie, Holmes) that Anel did not know what he was doing, did not appreciate the importance of the method, the mode by which it effected a cure, and its applicability to other aneurisms than those at the elbow, and that, as he used it, it was radically defective in placing the ligature too close to the sac, and without the intervention between the two of any collateral branch given off from the artery; that, in short, it was a mere happy chance, stumbled upon without reflection, and passed without appreciation; that Desault's, in like manner, was a mere experiment, but that Hunter's was the result of profound reflection and reasoning upon the nature of the disease and the manner in which coagulation of the blood in the sac is effected, and especially of his knowledge of the fact that complete shutting off of the current from the sac was not necessary. The original reports, on examination, do not appear to justify any of these claims, which seem to have no more solid basis than ignorance of what Anel and Desault really thought, and the crediting of Hunter, before his operation, with knowledge which he obtained at a later period. Hunter's identification with the operation was in large part the result of his exceptional authority at the time, the publicity which attended or was given to the act, the frequent repetitions, and the generalization which promptly followed it, and also of the great ability with which he set forth the principles upon which it rested. These in themselves are an ample title to recognition and respect, and Hunter's glory may well be left to rest on them without robbing others of their just due.

Three months after Desault's first operation, and three months before Hunter's first operation, at a consultation held in London on a case of femoral aneurism as large as an orange, in which Hunter took part, all agreed that it was impossible to resort to the operation ordinarily practised upon aneurisms, and recommended pressure on the artery in the groin; the attempt was made, and abandoned because of the pain it caused. It is apparent that at this time Hunter had not developed his method. The arguments that led Hunter to tie the femoral artery for popliteal aneurism, according to Home, his pupil, assistant, and reporter (*loc. cit.*, p. 145), were "that the disease often extends along the artery for some way from the sac; and that the cause of failure in the common operation arises from tying a diseased artery, which is incapable of union in the time necessary for the separating of the ligature." . . "If the artery should afterward give way [if tied just above the sac], there will not be a sufficient length of vessel remaining to allow of its being again secured in the ham. To follow the artery up through the insertion of the triceps muscle, to get at a portion of it where it is sound, becomes a very disagreeable part of the operation; and to make an incision upon the fore part of the thigh, to get at and secure the femoral artery, would be breaking new ground, a thing to be avoided, if possible, in all operations. Mr. Hunter, from having made these observations, was led to propose that in this operation the artery should be taken up in the anterior part of the thigh, at some distance from the diseased part, so as to diminish the risk of hemorrhage and admit of the artery being more readily secured, should any such accident happen. The force of the circulation being thus taken off from the aneurismal sac, the progress of the disease would be stopped; and he thought it probable that, if the parts were left to themselves, the sac with its contents might be absorbed and the whole of the tumor removed; which would render any opening into the sac unnecessary."

It is plain, from this, that Hunter's idea in seeking the artery at a higher point was simply to avoid secondary hemorrhage and to make its treatment, if it should occur,

* Everard Home, in Transactions of a Society for the Improvement of Medical and Surgical Knowledge, London, 1793, p. 148. This appears to be the first official publication of the case; the paper is not dated, but it is printed between two which are dated September, 1789, and September, 1790, respectively.

easier; and the extent to which this idea preoccupied his mind is shown in the strange additional precautions he took in the matter of the ligature itself. He tied the artery with four ligatures, "but so slightly as only to compress the sides together. . . . The reason for having four ligatures was to compress such a length of artery as might make up for the want of tightness, it being wished to avoid great pressure on the vessel at any one part."

According to Mr. Holmes, "the great merit of Hunter consists in his having seen, *first*, that it was not necessary to turn the clots out of the aneurismal tumor; . . . and, *second*, that it was not necessary to stop the circulation through it absolutely, but only, as he said, 'to take off the force of the circulation.'" The first of these was certainly appreciated by Anel and Desault, for they saw their patients get well; the second is difficult to explain, if it is based upon the fact that the ligatures were tied loosely, for they certainly were intended to, and did, cut out, and therefore occluded the artery entirely; and in Hunter's subsequent operations he used a single ligature and tied it tightly, so that if this was his opinion and object at first, he subsequently abandoned it. The idea, moreover, is expressed by Home (*loc. cit.*, p. 156) as a conclusion drawn from what was found at the autopsy eleven months later: "The conclusion to be drawn from the above account appears a very important one, viz.: That simply taking off the force of the circulation from the aneurismal artery is sufficient to effect a cure of the disease, or at least to put a stop to its progress." It seems much more reasonable to infer that Hunter's object in tying the ligatures loosely was to give the artery more time to become sealed before the ligature cut through. (See the first quotation from Home given above.)

The statement has been generally quoted as meaning that Hunter proposed to leave one or more collateral branches between the ligature and the sac, but there is nothing in the account of the operation or of the autopsy to justify such an opinion. "The femoral artery was impervious from its giving off the arteria profunda as low as the part included in the ligature, and at that part there was an ossification for about an inch and a half along the course of the artery. . . . Below this part the femoral artery was pervious down to the aneurismal sac, and contained blood, *but did not communicate with the sac itself, having become impervious just at the entrance* [italics mine]. . . . The popliteal artery, a little way below the aneurismal sac, was joined by a small branch, very much contracted, which must have arisen from the profunda, or the trunk of the femoral artery." This is the only collateral branch mentioned, and I do not see how the conclusion can be avoided that even if the phrase "to take off the force of the circulation" meant any more than "to arrest" or "cut off" the circulation, it meant only that the artery was left containing blood, and that this blood was in communication with that brought to the lower part of the same artery by collaterals coming from above the ligature. It would be interesting, too, to know by what "profound reasoning Hunter excogitated the principle" (Holmes) of including the vein in the ligature with the artery.

Even if Hunter afterward declared the presence of a collateral branch between the ligature and the sac to be a favorable condition, it does not affect the original conception; and furthermore, the existence of such a collateral branch is not essential to the method, and it is not found when the carotid or femoral is tied, or in some cases when the external iliac or subclavian is. In short, the method as now employed is to place the ligature at the nearest convenient point, sufficiently far above the sac to find the artery probably healthy; and the claim that has been made that complete arrest of the circulation is more dangerous than partial arrest, because it leads to the formation of a passive clot which is likely to provoke suppuration of the sac, has been proved, especially by the experience with the Esmarch bandage, to be incorrect, or at least the danger of exciting suppuration is much less than was claimed.

The changes within the sac by which a cure is effected after ligature are similar to those above described as effecting a spontaneous cure. The closure of the artery relieves the sac from all expanding pressure, except the slight amount which may be exerted by the blood that comes into the artery below the sac or between it and the ligature through collateral branches. The pressure being removed, the sac shrinks, the blood within it either coagulates in mass, forming a dark passive clot, or a slight movement persists in it and laminated fibrin is deposited on the wall. Pulsation in the sac ceases as soon as the ligature is tied, and usually remains permanently absent, but in some cases it returns after a longer or shorter interval and lasts for a few hours or days. This return is due to the freedom and rapidity with which the collateral circulation is established. The blood leaves the artery through the branches given off above the ligature, which dilate to accommodate the increased supply, makes its way through the minute terminal branches and capillaries into the terminals of the branches given off from the main artery below the ligature, passes through them in the retrograde direction, and thus regains the main artery to be distributed as before through its terminal branches. The greater the length of artery that has been obliterated by the ligature and disease, the greater the difficulty of the re-establishment of the circulation, and thus it is found that when two or three aneurisms are situated upon a single artery, or when, on account of secondary hemorrhage, a second ligature has been placed upon the artery at a higher point, the probability is great that the circulation will be re-established too slowly or imperfectly to preserve the life of the tissues, and the occurrence of gangrene is to be feared.

The method of operation is to expose the artery by a suitable incision, denude it just sufficiently to allow an aneurism needle to be passed under it, and to tie it with antiseptic catgut or silk. Both ends of the ligature are cut short, and the wound closed.

The chief dangers of the operation are secondary hemorrhage and gangrene. Before the introduction of the antiseptic method these dangers were so great that the mortality, after ligature of the femoral, for example, was about twenty-five per cent. They are now very much less. In twenty-nine cases of ligature of the principal arteries with catgut, by New York surgeons, which I collected in 1880 (*Am. Jour. of the Med. Sciences*, January, 1881), there was no secondary hemorrhage, and only one case of gangrene; the latter was of the foot, after ligature of the common iliac artery, and was followed by recovery. The diminution of the risk of secondary hemorrhage is plainly due to the avoidance of suppuration about the ligature, and the freedom from gangrene appears to me to be the result of the same rapidity and ease of healing, through diminution of the interference with the vein by the inflammatory process.

The attempt has been several times made to diminish the chance of the occurrence of gangrene by repeatedly compressing the artery above the aneurism for several days before tying it, in the hope of thereby gradually enlarging the collaterals, and better fitting them for carrying on the circulation when it is finally thrown entirely upon them. The result has not borne out the expectation; on the contrary, gangrene has followed the attempt in a larger proportion of cases than when the artery has been tied without preliminary compression. A satisfactory explanation has not been found.

Other ill results of the ligature of the main artery of a limb may be permanent deterioration of its nutrition, loss of nerve and muscular power, persistent or recurrent ulceration of the skin, and suppuration of the sac.

In order to diminish the chances of the occurrence of gangrene, the limb should be wrapped in cotton immediately after the operation, and kept thus protected from losing heat until the circulation is shown to be fully re-established. If its temperature is found to remain too low, external heat should be cautiously applied in the form of hot bottles, bricks, or sand, but care must be

taken that the heat thus applied is not much above the normal body heat, lest it should cause blisters.

Suppuration of the sac may occur, and either cause spontaneous rupture or make an incision necessary. The opening may be followed by dangerous hemorrhage, or the communication between the sac and the patent portion of the artery may have previously become permanently obliterated. Sometimes pressure is sufficient to arrest the hemorrhage and lead to a final cure by granulation; in other cases, the clots will have to be turned out and all bleeding points secured, or a second ligature may be applied *between* the first one and the sac. A second ligature *above* the first greatly exposes to gangrene.

If pulsation returns permanently in the sac and the tumor again begins to grow, several courses are open to the surgeon. If the aneurism is at the knee, groin, or elbow, flexion should first be tried, and this failing, perhaps galvano-puncture, the injection of persulphate of iron, or acupuncture; if resort to operation becomes necessary, the artery may be tied again between the first ligature and the sac, or the "old operation" of incision into the sac and ligature of all vessels entering it may be done. Both methods have proved successful.

The numerous statistics that have been collected of the various results following treatment by ligature do not furnish a fair basis for estimating the chances after ligature with antiseptic catgut or with silk, and treatment of the wound by modern methods. Mr. Holmes' statistics, in 1874,[5] gave 13 deaths in 87 cases of popliteal aneurism treated by the ligature, a mortality of nearly 15 per cent., say 1 in 7; while 9 cases of ligature of the femoral, 3 of the external iliac, and 1 of the primitive iliac under the antiseptic method, collected by myself in 1880,[6] gave no deaths, no secondary hemorrhage, and only partial gangrene in 1, that of the primitive iliac. There is, therefore, good reason to believe that the operation has become, under antiseptic methods of treatment, much less serious than it formerly was.

In like manner the aseptic ligature has caused the entire abandonment of various devices (metallic ligature, artery constrictor) designed to diminish the chance of the occurrence of secondary hemorrhage.

(*b*) Compression of the artery, direct, indirect, and digital. Direct compression is made upon the artery by acupressure needles or wires, threads, or forceps, after incision of the skin and exposure of the vessel; indirect compression is made by suitable instruments or weights resting on the surface over the artery; digital compression is made by the fingers.

Indirect compression is an older method even than ligature of the artery, and was employed, although unsuccessfully, by Desault in the treatment of an axillary aneurism a few months before he first treated a popliteal aneurism by ligature, as mentioned above. It is claimed for Hunter, also, that he was the real originator of the treatment by compression, because he showed that complete arrest of the circulation was unnecessary, and that the compression might be partial or intermittent, and because all previous operators sought to effect a cure by obliterating the artery at the point pressed upon, a statement which does not appear to be borne out by the reports of their cases. However that may be, the former theory that a passive clot was a source of danger, and that persistent pressure upon the artery to arrest the circulation for several hours was, therefore, a more dangerous method than intermittent or incomplete arrest, which would give a laminated clot of slow formation, is now abandoned, and, as a rule, when compression is used, it is with the aid of anæsthesia or morphine, is forcible enough completely to arrest pulsation in the sac, and is continued until the contents of the sac have coagulated. Intermittent, incomplete arrest is occasionally used under exceptional circumstances. In a few cases in which pressure above the sac could not be made, complete arrest of the circulation below it, usually by the elastic bandage, has effected a cure (see Distal Ligature, further on).

The method of cure by this means varies in the different cases; in some it is by the deposit of laminated clot, in others by a soft passive clot. The changes in the aneurismal sac are the same as those above described, and the dangers of the method are the same as after ligature, with the exception of secondary hemorrhage. A unique consequence, reported by Mr. Pemberton,[7] was the formation of a communication several months afterward between the artery and vein at the point where pressure had been made, resulting in an arterio-venous aneurism that finally caused the patient's death.

The operative methods include the use of weights or of special instruments having the general character of a truss. The latter are numerous and varied, but all consist essentially of a branch to make counter pressure without circular constriction of the limb, and of a pad which can be screwed or bound down upon the artery with suitable force. For weights, bags of shot are used, or pieces of lead moulded to fit the parts. They may be allowed to rest entirely upon the limb, or may be suspended by an elastic cord.

Prolonged complete arrest of the current requires the aid of anæsthesia, for the pressure soon becomes very painful; anæsthesia may be safely prolonged for many hours. It is well to aid the control of the circulation above by pressure also below, or by tightly bandaging the limb below the aneurism.

Digital pressure, which had previously been employed in two cases as an aid to compression by instruments, was first used as the sole means of cure by Dr. Jonathan Knight, of New Haven, Conn. The case was one of popliteal aneurism, and a cure was effected in about two days. The plan has since been employed in a large number of cases, and with a large measure of success. Fischer's statistics, quoted by Holmes, contain 90 cases, with 76 complete cures, and 8 deaths; 6 of these deaths occurred after subsequent ligature, the remaining 2 after amputation. In about one-third of the successful cases the cure was effected within twenty-four hours.

Digital pressure can be made only with the aid of a considerable number of assistants, and it is usual to employ them in pairs, one making pressure while the other feels for pulsation in the sac. The skin should be covered with French chalk at the point where the pressure is made, and the assistants should be carefully instructed as to the amount of pressure needed and the place where, and direction in which, it should be made. When the change is made from one assistant to another, the latter should place his finger or thumb upon the artery immediately above or below that of the one whom he replaces, and this one should not remove his finger until after the artery is duly compressed by the other. Ether or morphine should be used when the patient begins to complain of the pain.

Direct compression of the artery by needles or wire or forceps, after incision of the overlying parts, is a substitute designed to arrest the current more certainly than is done by indirect pressure, and yet to avoid the risk of secondary hemorrhage. It is to be regarded rather as a substitute for the ligature, and as such has become much less important since the introduction of the catgut ligature and the antiseptic method, although under exceptional circumstances, as with large arteries and near large branches, it may still be advisable to resort to it. The instances in which the method has been used are not numerous, and the varieties in the means employed are almost as numerous as the cases. Acupressure, after use in a very few cases, seems to have been entirely abandoned. Mr. Bickersteth[8] compressed the innominate with a leaden wire drawn loosely around it; the wire broke on the second day; a ligature was then applied, and the patient died of hemorrhage on the sixth day. Mr. Dix[9] cured an aneurism of the carotid and another of the femoral by passing a wire under the vessel, bringing both ends out through the tissues at the side of the wound, and twisting them over a piece of cork tightly enough almost to stop the pulsation. The wire was tightened on the third day and removed on the fifth or

sixth. Porter[10] compressed the innominate for three days with an instrument resembling a small lithotrite; fatal hemorrhage from the vessel at the point compressed occurred on the tenth day. Robert Perssé White[11] compressed the external iliac for one hundred and sixty-two hours with a modified form of Porter's instrument, and thereby cured an inguinal aneurism. Dr. W. Stokes, Jr. compressed the abdominal aorta with a silver wire tightened over a ring, after a plan recommended by Porter, and Mr. Holmes says the vessel was so firmly closed after pressure for a few hours that at the autopsy water could not be forced through it; the patient died of peritonitis.

Mr. McGill[12] compressed the first portion of the left subclavian with ordinary torsion forceps; after nine and one-half hours the aneurism was solid and pulseless, and the instrument was removed. The patient died of pleurisy, the pleura having been opened during the operation; previous to this operation the aneurism had been much benefited by galvano-puncture.

(c) Compression by Esmarch's elastic bandage. This method was first employed in 1875 by Dr. Walter Reid, of the British navy, in a case of popliteal aneurism. The bandage was applied tightly to the leg, loosely over the tumor, and then tightly over the lower third of the thigh; then the cord was put on and the bandage removed. At the expiration of fifty minutes the pain had become so great that the cord was removed, two Carte's compressors on the upper portion of the femoral artery having been substituted. At the expiration of three hours from the commencement the aneurism was found to be pulseless; intermittent pressure was kept up for two days, and then the patient was pronounced cured. The condition of the parts found at the death of the patient a few months later, and the method by which this treatment appears to effect a cure, have been described above. In January, 1881, I collected 62 cases treated by this method,[13] which may be grouped in three classes, according to differences in detail. In the first class, 52 cases, Dr. Reid's method was followed exactly or very closely; in the second class, 5 cases, the rubber tubing or the elastic bandage was used repeatedly and alternately with the tourniquet or digital pressure to arrest the circulation for several hours; in the third class, 5 cases, the bandage was used for a short time daily for many successive days, without any compression of the artery in the intervals, or with a tourniquet loosely applied. In the first class there were 28 cures, 22 failures, and 2 deaths; and of the cures 24 were obtained by a single attempt continued for about an hour on the average, the extremes of time being fifty minutes and three and one-half hours, and 4 by two attempts each, separated by an interval of from one to four days. After the removal of the bandage the artery was compressed with a tourniquet or the fingers, usually for a few hours, but in one case for only one hour, and in another for five days. In 2 or 3 cases pulsation returned in the aneurism on the following day, and was then definitely arrested by compression for a few hours. In 12 of the 22 failures the same method was used in nineteen different attempts; in the remaining 10, with eighteen attempts, no pressure seems to have been made after the removal of the bandage. In at least 5 of the 12 the method was skilfully employed, with every detail used in most of the successful cases; they show, therefore, when added to the 28 cases treated successfully by this method, that it may be expected to fail in at least 15 per cent. of the cases. As for the remaining failures, there is some reason to suppose that the method was not carried out with as much care and attention to details as it was in the others.

A very important fact is that the method appears not to involve any serious risk, and not to diminish the chances of success if resort is subsequently had to the ligature. Of the two fatal cases, in one the bandage was applied twice with an interval of three days, and retained in the last trial for nearly eight hours. The patient died twenty-seven hours afterward with symptoms of heart failure or shock, the dorsum of the foot remaining cold. In the other the aneurism (of the anterior tibial artery) had ruptured externally, and amputation was strongly urged, but refused by the patient; gangrene of the foot and lower part of the leg followed, and the patient died during the second week. The circumstances in each case were quite exceptional. Mr. Bryant applied the bandage twice for three hours each time, with an interval of four days, in a case of popliteal aneurism in a man forty-five years old. A fortnight after the second attempt he tied the femoral artery with catgut, the wound healed by immediate union, but "anæmic gangrene" followed and the leg was amputated. This is the only instance of gangrene in the 16 cases in which the ligature was resorted to after the bandage had failed to produce a cure.

The conclusion to be drawn from all these cases seems to be that we have in the elastic bandage an efficient means for safely shortening the duration of the treatment by compression of popliteal and some femoral aneurisms. The greater efficiency, the more speedy action of the method is apparently due mainly, if not entirely, to the arrest of the circulation through the collateral channels as well as through the main artery, thus securing absolute stagnation of the contents of the sac. Consequently the rubber tubing, which is drawn tightly twice or three times about the limb above the aneurism, is to be deemed the efficient part; and the principal, perhaps the sole benefit from the bandage is that of making a less severe constriction by the tubing sufficient.

The method of carrying out this procedure is simple: thus, in popliteal aneurism, the bandage should be applied tightly to the leg, loosely over the aneurism, and tightly again above it, and the bandage or the tubing should be kept in place for one or two hours; then the artery should be compressed by a tourniquet or the fingers for several hours afterward, the compression being occasionally intermitted for a moment to see if pulsation returns in the sac. If pulsation returns within a few hours, the artery must be again compressed. The introduction of needles or a coagulating injection might be proper in connection with a second trial after a failure.

(d) Compression by flexion of the limb. When an aneurism is situated at the bend of a joint, pulsation in it may sometimes be diminished or arrested by flexion of the joint, and this fact has been occasionally utilized, either as the principal means of treatment or as an adjuvant thereto.

The method appears to have been first suggested by Fleury, a French surgeon, in a paper published in the *Journal de Chirurgie*, in 1846, as an inference from his success in curing a wound of the brachial artery at the elbow by flexion. In 1852 the suggestion was put into practice by Thierry in a case of traumatic aneurism at the elbow, and in 1857 a large popliteal aneurism was cured by flexion of the knee by Maunoir, of Geneva. He tried at first to keep the leg forcibly flexed upon the thigh, but the patient could not endure the pain, so he had to be content with keeping it partly flexed by a strap crossing the shoulders, while the patient went about on crutches. This was kept up about three weeks, at the end of which time the tumor had ceased to pulsate.

Flexion has been used successfully in aneurisms of the popliteal artery, at the groin, and at the elbow. Of 49 cases of popliteal aneurism treated by flexion, analyzed by Liégeois, 26 were cured, in 11 of which flexion alone was used, in 11 others flexion in combination with other means, and in 4 flexion after other means had failed. It was first used at the groin by Dr. Gurdon Buck[14] at the New York Hospital in an aneurism which had recurred sixteen months after apparent cure by compression. Pressure on the external iliac did not arrest the pulsation, and flexion was tried as the only alternative for treatment by laying open the sac. In a case of inguinal aneurism treated by Dr. Eldridge, of Yokohama, a cure was obtained by keeping the thigh flexed upon the pelvis for twenty days.

In making use of the method it seems to be usually necessary to carry the flexion to a point at which it markedly diminishes the pulsation in the tumor, and

perhaps arrests it entirely, and then to keep the limb in this position for a long time by suitable bandages or apparatus. It is well, also, in popliteal aneurism, to bandage the leg up to the knee to prevent swelling. The merits of the method lie in the facility with which it can be carried out, and in the freedom from the chance of accidents if care is taken not to make too forcible pressure.

3. Permanent arrest or obstruction of the stream on the distal side.

(*a*) By distal ligature (Brasdor's and Wardrop's methods). Distal ligature, first suggested by Brasdor and Desault toward the end of the eighteenth century, was first performed by Deschamps in 1798; the femoral artery was tied in the middle of the thigh for the cure of a large aneurism, the upper border of which was less than a finger's breadth below Poupart's ligament. As rupture of the sac threatened on the fourth day, the artery was compressed on the pubis, the sac opened, and the vessel tied above and below; the patient died eight hours afterward. The operation was next performed by Sir Astley Cooper, who tied the common femoral artery below the epigastric for a large aneurism of the external iliac; the patient recovered from the operation, but the aneurism continued to pulsate and soon afterward ruptured. In 1825 Wardrop obtained the first success, tying the common carotid on the distal side of a large aneurism in a woman fifty-seven years old. Wardrop's efforts to popularize the operation, and especially his extension of it to aneurisms of the innominate artery, have permanently associated his name with it as distinctive of that form in which the current is not completely arrested, but continues only through branches given off from the artery between the ligature and the sac; while the name of Brasdor is given to that form in which there are no such branches and the arrest of the current is complete.

The operation is practically limited to aneurisms at the root of the neck, those of the common carotid, subclavian, and innominate. In some cases in which an aneurism of the arch of the aorta has been mistaken for an innominate aneurism, and the carotid and the subclavian in its third portion have been tied, marked relief of symptoms has followed, and in two or three cases the left carotid has been tied for recognized aortic aneurism. The operation benefits by arresting or retarding the circulation in the vessel and sac and thus favoring the formation of a laminated clot. The anticipation that the pressure within the sac would be increased by the distal ligature has proved unfounded, and the first effect of the operation has often been an immediate decrease in the size of the aneurism and in the force of its pulsation.

The proportion of successes previous to the introduction of the antiseptic ligature was very small, but with the introduction of this form of ligature the operation appears to have entered upon a new career of usefulness and of applicability to cases that have heretofore been beyond aid by surgical art. In eight cases of ligature of the carotid and subclavian for innominate aneurism in which catgut was used,[15] death was caused by the operation in only one, and other successes have been since reported. It is, of course, less certain in its action than ligature on the proximal side, and its use will therefore be restricted to cases in which the proximal ligature or compression is impossible or too dangerous—in other words, to aneurisms at the root of the neck, and perhaps of the external or common iliac. It is to be judged not by comparison of its proportion of successes with that of other methods, but rather as a grave alternative in a limited class of cases that are open to few other means of treatment, and that lead inevitably, if left to themselves, to prompt and certain death.

(*b*) Manipulation or malaxation of the aneurism. This method, introduced by Ferguson in 1852 and employed twice by him, rests upon the same principle as the distal ligature—arrest or diminution of the current by an obstacle placed upon the distal side of the sac. In this method the obstacle is a fragment of old clot mechanically displaced from the wall of the sac and lodged within the artery. This displacement of a clot is thought to be the mechanism by which many of the so-called spontaneous cures have been obtained. The conditions essential to its employment are the presence of enough laminated clot in the sac to make the detachment of a piece of sufficient size possible and practicable by external manipulation, and the impossibility of safely resorting to other methods of treatment. The latter condition limits the method to a small number of cases, mainly those situated upon the subclavian artery. It is inapplicable to those situated upon the carotid, because of the certainty that small fragments will pass into the arteries of the brain and become cerebral emboli, with consequent paralysis. This accident has been observed also in cases of aneurism of the right subclavian treated in this manner, and in one of the arch of the aorta, mentioned above, in which the projecting sac was pressed back through an opening in the sternum. Rupture of the sac, which has been feared on theoretical grounds, has not occurred in any of the reported cases.

In a case reported by Mr. Little, the result was most satisfactory, and the method deserves all the more credit from the fact that apparently no other could have been employed with any hope of success. The patient was fifty-three years of age, the aneurism was of the right subclavian, had lasted nine months, was of considerable size, and pulsated strongly; the overlying skin was inflamed. January 1, 1856, Mr. Little[16] made steady pressure with the thumbs on the sac, and succeeded in displacing some of the clot and directing it toward the distal opening. During the first two days no change was noticed; on the third the pulse, at the wrist, was weaker and the arm colder, and by the tenth day no pulsation could be felt in any of the arteries of the arm. The tumor became gradually solid and ceased to pulsate, and shrunk to the size of a small walnut. The arm remained cold and partly paralyzed for a time, but a year after the operation the cure was complete and satisfactory in every respect.

4. Rapid coagulation of the blood in the sac, with or without temporary arrest of the stream.

(*a*) Coagulating injections. This also is a method of very limited applicability; it can be used only as an adjuvant to other methods, or in exceptional cases, as of recurrence or of pouched aneurisms. Dr. Joseph C. Hutchison, of Brooklyn, employed it unsuccessfully in a case of aneurism of the abdominal aorta. It has been considered essential to its use in the treatment of an aneurism of the common or encysted variety that the circulation through the sac should be completely commanded during the injection and for some time thereafter, but if this condition can be fulfilled, treatment by distal or proximal compression or ligature will usually be possible. In certain other varieties, as cirsoid aneurism and varicose aneurism at the elbow, it has yielded good results.

The coagulating substance has almost always been a solution of an iron salt, the subsulphate, lactate, or perchloride. The coagulating power of the latter is great, but so, too, are its escharotic qualities, and its use has commonly been followed by suppuration of the sac. A strength of 20° Beaumé seems to be as great as should be used, and the quantity is set by Holmes at eighteen or twenty drops for an aneurism of the size of three and one-half ounces. Van Buren thought the preference should be given to the subsulphate, which is not at all escharotic. Dr. Hutchison made nine injections of from five to fifteen minims each, in a case of recurrent femoral aneurism, without obtaining any benefit or causing any irritation; the strength of the solution varied from one in five to one in thirty. In a case of aneurism of the innominate, for which Dr. Eliot[17] tied the carotid and subclavian arteries, ten and one-half drachms of a solution of the subsulphate were injected on the seventeenth day after the operation to arrest hemorrhage from the sac. This was followed by a discharge of bloody serum for three days, and protrusion of a dry clot, which fell out on the twenty-fourth day, leaving a large cavity, from which fatal hemorrhage took place on the twenty-sixth day.

its subsequent course are then the same, but during the stage of formation of the sac the conditions present symptoms of dangers peculiar to itself. There is the history of the injury, absence or diminution of pulsation in distal branches, local swelling and ecchymosis, and sometimes marked lowering of the temperature of the limb. There is usually a bruit but no pulsation in the swelling at first, but, after the sac has formed, the expansive pulsation characteristic of an aneurism is present.

During the formative stage of the sac the injury is peculiarly amenable to treatment by direct pressure at the seat of injury; and often after the sac has formed a cure may be effected by the same means. This is the one important practical point of difference between traumatic and spontaneous aneurisms.

When the injury is associated with fracture of a bone the immediate treatment, unless the symptoms are very alarming, should be confined to securing the repair of the fracture and to limiting the extravasation of blood by suitable pressure, and the treatment of the aneurism should be postponed, if possible, until after the bone has united. The presence of the extravasated blood is not a serious obstacle to this repair, while the conversion of the fracture into a compound one by an incision made to secure the wounded artery may have very serious consequences.

Exceptionally, the extravasation may be so free as to endanger the vitality of the limb by its interference with the circulation, and under such circumstances the surgeon may be compelled to turn out the clots and secure the vessel, or even to amputate. This is much more likely to be the case in complete rupture of the artery, when none of the blood brought by the artery is carried past the injury into its distal branches, but all is poured out into the tissues, and, being bound down by the enveloping fascia, exerts a pressure which checks the venous flow and prevents the establishment of collateral circulation. This condition is characterized by great and uniform swelling, absence of pulse, and notable loss of temperature in the limb.

II. ARTERIO-VENOUS ANEURISM.—When an abnormal direct communication is established between the trunk of an artery and that of a neighboring vein, the condition is known as an arterio-venous aneurism. When the two vessels remain in close contact, and the blood passes directly from the artery into the vein, the variety is known as *aneurismal varix*, the prominent feature being a varicose dilatation of the vein. When, on the other hand an aneurismal pouch is formed by condensation of the adjoining tissues, the variety is known as a *varicose aneurism*, or as an arterio-venous aneurism in the narrow sense. In the great majority of cases of varicose aneurism the aneurismal sac is intermediate between the artery and the vein, and blood passes through it on its way from the former to the latter. Broca describes a subvariety, in which the artery and vein communicate directly with each other and there is an aneurismal pouch lying on the opposite side of the artery. Probably the distinction could not be made during life. In some of the classifications any case that presents a distinct aneurismal tumor, whether enclosed by a sac of new formation or by one formed by circumscribed dilatation of the vein, is called a varicose aneurism; but the latter variety, that in which the aneurism is formed by dilatation of the vein, seems to be much more closely allied in every way to aneurismal varix.

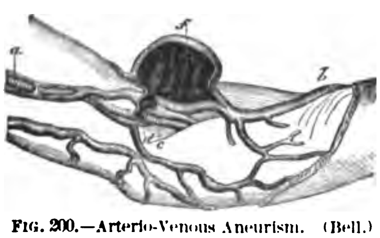

FIG. 200.—Arterio-Venous Aneurism. (Bell.)

The common cause of this affection is a wound involving both the artery and the vein; but in some cases the communication forms by ulceration of the wall of the vein where it is pressed upon by an aneurism, and in one case (reported by Pemberton in Med.-Chirurg. Trans., vol. xliv., p. 189) an arterio-venous aneurism formed at the groin ten months after prolonged instrumental pressure had been made at that point to cure a popliteal aneurism. The most frequent cause by far, in the past, has been the wounding of the artery in venesection at the elbow. The cause in recent times is a gunshot or stab wound. Another occasional cause is fracture of the base of the skull, by which the carotid artery is torn in the cavernous sinus. Spontaneous formation by rupture of an aneurism into a vein is rare, and almost confined to thoracic and abdominal aneurisms.

The pathological changes which are found in this class of aneurisms vary greatly in their details, according to the character and extent of the primary injury and of the communication between the vessels, and to the distance of the vessels from the heart. The principal factor in the production of these changes is the extent to which the intra-arterial pressure is transferred to and exerted upon the wall of the vein and the aneurismal sac; and this is determined by the size of the opening in the artery and by the resistance offered to the return of the blood through the vein to the heart. Hence, when the communication is between an artery and a large venous trunk, such as the internal jugular, which can readily carry away the excess of blood almost as rapidly as it is supplied, the distending force is not much exerted and the obstructive changes in the vein are slight; but when the communication is between an artery and a vein in one of the extremities, or in the head, an immense aneurismal pouch may be formed or the veins may become greatly dilated and varicose. The pouch usually has a smooth internal surface and contains little or no stratified clot, and when it is formed in great part by dilatation of the vein, the orifices of other veins opening into it are seen at various points, and these veins are enlarged and their walls thickened.

The artery below the point of communication is smaller than normal, and if it has been entirely divided by the original injury, the lower portion may be occluded at the point of division; the end of the upper portion is kept open by the stream of blood.

The symptoms vary somewhat with the pathological changes; there may be a well-defined pulsating tumor, presenting the usual features of an aneurism and the special ones peculiar to this variety, or there may be simply a diffused swelling of the region, or the superficial adjoining veins may be markedly varicose. The special features are the bruit and the thrill. The bruit is continuous, with a systolic reinforcement; it is most intense immediately over the point of communication between the vessels, and becomes less, or may be changed into an intermittent murmur, as the distance from this point increases. This apparent intermittence is due simply to the fact that the portion of the murmur which corresponds in time to the contraction of the heart is louder than the rest, and is heard at a distance at which the latter has become inaudible. In some cases the murmur could be heard at a great distance along the vessels; thus in one quoted by Follin, it could be heard from the elbow to the heart, in another (of the femoral), from the head to the feet. The *thrill* is a peculiar sensation given to the hand when laid upon the aneurism, a vibration that has been compared to the purring of a cat.

The interference with the circulation below the point of communication is commonly well marked, and is shown by swelling of the limb which is not œdema, but which, in some cases at least, is an actual hypertrophy, and is accompanied by a permanent elevation of the temperature of the limb, by a greater growth of hair upon it, and in one case by an increase of an inch in length. There is a feeling of numbness or of actual pain in the limb, increased by its use, and there may be a marked loss of muscular power, and sometimes persistent ulcers or eczema.

The lesion may fail to become apparent until some time after the receipt of the injury (four years in one

case), and commonly it remains stationary after having reached a certain development. Those situated upon the great vessels, the carotid and internal jugular for example, seldom cause any inconvenience to the patient. In a few cases the opening into the vein has closed spontaneously, and the aneurism has been thus transformed into a simple arterial one.

Treatment.—In recent cases carefully graduated, direct pressure has sometimes availed to close the opening, and this may be aided by compression of the artery above. Operative interference in the past, which has included a variety of methods, has proved exceptionally dangerous, but the statistics for obvious reasons have lost much of their value with the improvement in operative methods and in the treatment of wounds. The operations may be divided into two main classes, according as the sac is or is not opened, and in the latter class they will further vary according to the number of the ligatures applied.

The question of interference will be determined by the extent of the disability and the number of vessels involved in the lesion. In the forearm or on the scalp it is usually practicable to tie all the vessels, arterial and venous, that are involved, and thus effect a radical cure. In the neck (carotid and jugular) the history of recorded cases[19] shows that the lesion rarely causes more than a moderate amount of inconvenience, that can be easily borne by the patient.

Ligature of the artery alone on the proximal side, in arterio-venous aneurism of the lower extremity, has proved remarkably fatal by gangrene. In 12 cases collected by Van Buren,[20] the external iliac was tied in 5 and the common femoral in 2, and gangrene followed in all; the femoral was tied in 5, and gangrene occurred in 2. This extraordinary frequency is presumably due to the easy return to the heart, through the opening into the vein, of the blood brought to the distal segment of the artery by the collateral branches; it fails to pass on and nourish the limb. Consequently a second ligature applied to the artery close below the opening, diminishes the chance of gangrene. Ligature of all the veins, as well as of the artery, suppresses all subsequent growth of the sac or continuance of the disease, but it adds a factor that is most important in the production of gangrene—obstruction of the venous flow. Moreover, the operative difficulties are extreme. The record of cases in which the sac has been opened and the attempt made to arrest all bleeding from it, is such as to discourage any one from undertaking it; again and again operators have had to resort to ligatures *en masse*, passed by means of curved needles, and more or less blindly, in deep, inaccessible corners of the wound, to the actual cautery, and even to styptics and pressure. The incision has always been very long, and the tissues have been bruised and lacerated by the prolonged search and dissection. In the only case I have witnessed, an aneurism of the upper part of the calf, the incision was more than a foot in length, the operation lasted about two hours, and, at the last, resort was had to persulphate of iron and graduated compresses packed deep in the wound. The wound could not be kept aseptic, and the patient died on the third day of acute septicæmia. The method seems to violate all the principles that govern modern methods of making and treating wounds, and it does so, in my opinion, in the effort to attain an end that is not only unnecessary, but introduces an element of great additional danger. If the double ligature of the artery alone is too dangerous to be employed, the more extensive operations are still more so. Whether or not the double ligature is too dangerous, under the modern improvements, is yet to be determined, but I am convinced that it is the only one which the surgeon should employ. In 1882, Professor Verneuil[21] treated an arterio-venous aneurism of the popliteal space by ligature of the artery and vein on the proximal side. After the ligature had been applied and the tourniquet removed, the tumor filled slowly with blood, and the surgeon then opened the sac and sought to secure all the vessels that opened into it. The patient recovered, but in the remarks which the distinguished surgeon made upon the case (*loc. cit.*, p. 276), he expressed his regret that he had opened the sac. He does not explain why he tied the vein as well as the artery; doubtless he had a good reason for it, but, in ignorance of that reason, it seems to me a mistake to oppose the escape of blood from the sac toward the heart. Probably he sought to effect a cure, as in other aneurisms, by inducing coagulation and obliteration, and deemed it inadvisable to allow the venous stream to pass through the dilated and varicose veins. The case is quoted to show what others have also shown, that a cure is possible, without gangrene, even under operative conditions that favor the occurrence of that complication, and that a like favorable result may be expected in a proportion yet to be determined, from the less difficult and dangerous operation of double ligature of the artery.

A few successes have been obtained by galvano-puncture and by the injection of coagulating solutions without ligaturing any vessel, and quite recently, in a few cases in which the changes were not very extensive, the sac has been successfully extirpated.

III. Cirsoid Aneurism (arterial varix; aneurism by anastomosis).—This name has been given to an affection of the arteries, sometimes involving also the capillaries and even the derived veins, which differs materially from that which constitutes the common variety of aneurism, and is characterized by a uniform or irregular dilatation and tortuous lengthening of an artery and its branches. The affection is most common in the superficial arteries of the head—the temporal, occipital, and auricular—but it is also found in the hand, forearm, leg, and even involving the external iliac artery.

The change consists in a dilatation and lengthening of the artery, with atrophy of its middle coat and consequent thinning of the wall, or possibly with hypertrophy by thickening of the middle coat in the early stages; the dilatation may make the calibre of the vessel ten times larger than normal, and may be uniform, but is usually accompanied by the formation of small pouches. In consequence of the lengthening the artery assumes a tortuous form. The change has a marked tendency to spread in both directions, involving the arterial branches and even the consecutive capillaries and veins, and in the latter case it is known as *aneurism by anastomosis* or *racemose aneurism*. There is also reason to think that in some cases the change has originated in a nævus and has spread backward to the arteries. At the central portion of the tumor, where the tortuous and dilated vessels are most numerous and closely packed, there may exist, as Lefort[22] has pointed out, a sort of central lake, as in cavernous angioma, or a real aneurism, or even an arterio-venous aneurism. The overlying skin and soft parts may be thinned, or thickened and indurated, and the underlying bone may be absorbed in consequence of the pressure.

The principal causes are found in contusions and pre-existing erectile tumors or birth-marks, and the change takes place most frequently at the time, or shortly after, the age of puberty is reached. In what manner or through what agency these causes act is not known, nor why the region of the head is the common seat.

The symptoms of the disease are a soft, ill-defined swelling under the skin, in which numerous pulsating vessels can be felt, and into which tortuous arteries can be seen to pass. The overlying skin is reddened or livid, either by implication of its own minute vessels or by transmission of the color of the blood below it; the tumor communicates a sort of thrill to the hand, and a continuous murmur to the ear. In a complete typical case four distinct varieties of changes or lesions can be recognized: First, a cutaneous erectile tumor, formed by dilatation of the arterial capillaries of the skin; second, a subcutaneous arterial cirsoid tumor, formed by the dilatation of the finest arterioles under and around the first; third, dilatation and tortuosity of the main arteries leading to the tumor; fourth, dilatation of the veins coming from the tumor, sometimes with pulsations synchronous with those of the heart.

The affection is a serious one, because of its tendency to increase and the danger of hemorrhage through ulceration of the skin or an accidental injury.

Treatment has generally proved not only difficult, bloody, and dangerous, but also unsatisfactory as regards the cure of the disease. It comprises ligature of the main trunks from which the affected arteries arise, as of the temporal, or the external or common carotid, in cirsoid aneurism of the scalp; excision or incision of the tumor; caustics; galvano-puncture; and coagulating injections. Lefort (*loc. cit.*), who made a careful study of eighty-three cases, says that whenever treatment has been directed only to the afferent arteries, it has failed or has produced only an incomplete cure; but that, on the other hand, the obliteration of the vessels forming the central portion of the mass has been followed by the return of the afferent vessels to their normal condition. He claims, therefore, that the treatment should always be directed to this central portion. It includes three methods: removal or destruction of the mass by caustics or the knife, the injection of coagulating liquids; galvano-puncture. Removal by the knife exposes to severe hemorrhage, but, if practised with caution, is practicable and to be recommended when the central mass predominates. Destruction by caustics (chloride of zinc) seems to be without much danger of hemorrhage, but is slow and tedious and may cause superficial necrosis of underlying bone. Lefort recommends the injection of a solution of the perchloride of iron, which has given nine successes in ten cases; he prefers a five-per-cent. solution to the stronger ones. Dr. John Duncan[23] refers to four cases treated by electrolysis, three of them successfully. The variety known as aneurism by anastomosis, in which the capillaries and veins are also involved, is less amenable than the others to this method of treatment.

IV. Dissecting Aneurism.—This is a lesion occasionally found in the aorta, which has only a pathological interest, since it cannot be recognized with certainty during life and is not open to treatment. It consists of a partial rupture of the wall of the vessel, and the passage of the blood between its coats, usually in the substance of the middle coat, to a second opening into the lumen of the vessel at a lower point, or backward to one into the pericardial sac. The primary opening is usually in the arch of the aorta; the second one may be in the same vessel, or at a considerable distance in one of its branches—once in the subclavian, once even in the popliteal. When the flow is backward into the pericardium, death promptly follows; in other cases the period of survival is usually short, but may be prolonged for years, and under such circumstances the track followed by the blood develops a resisting wall lined with epithelium.

Lewis A. Stimson.

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ANEURISM, ABDOMINAL.—Etiology.—The principal *predisposing causes* of abdominal aortic aneurism are endarteritis and atheroma, which mainly originate in chronic alcoholism, rheumatism, or syphilis, and which act by impairing the strength and elasticity of the arterial walls. Atheroma is rather less frequently a precursor of abdominal than of thoracic aneurism.

The *exciting causes* consist in falls, blows upon the back or abdomen, sudden movements, and violent or prolonged muscular efforts. The disease accordingly exhibits a marked preference for middle-aged members of the laboring classes, and for the male sex, which furnishes about ninety per cent. of all the cases. The causative influence of excessive muscular exertion and of rapid changes in position depends upon the sudden increase of arterial tension resulting from augmented cardiac action, as well as upon the alternating elongation and relaxation of the aorta incident to movements of flexion and extension in the freely mobile lumbar portion of the spine. Blows and falls act as exciting causes in the same manner or by direct injury to the delicate internal and middle arterial tunics.

Morbid Anatomy.—Aneurisms of the abdominal aorta are, according to the statistics of Crisp, who analyzed 591 cases, only one-third so frequent as thoracic aortic aneurisms. They are usually located in the vicinity of the cœliac axis, often involving its orifice, but may affect any portion of the main trunk or any of its ramifications. Dr. Sibson, who tabulated 177 cases, found 131 aneurisms situated at or very near the cœliac axis. Quincke asserts that the site is more frequently *below* than above the axis. The branches most often involved are the common iliac arteries, the cœliac axis and its three divisions, the superior and inferior mesenterics, and the renal artery. Rather less than fifty per cent. of the aneurisms arise from the anterior aspect of the aorta. They are sacculated, according to Sibson, in sixty per cent. of the cases, and belong, ordinarily, to the false-sacculated, dissecting, or diffuse varieties. They often attain large dimensions, and exert injurious pressure upon adjacent viscera, notably upon the spine, the spinal cord and nerves, the solar plexus, the pancreas, the large and small intestine, the stomach, the kidney and its vessels, the vena cava, the psoas muscles, the receptaculum chyli, the thoracic duct, the branches of the aorta, and the aorta itself. This pressure frequently induces absorption of the neighboring soft tissues, with erosion of the vertebræ, of the intervertebral fibro-cartilages, and of the ribs, intimate adhesions having first been formed between these structures and the aneurism.

The arterial sac undergoes atrophy and absorption, occasioned by augmented intra-arterial and external pressure, and finally ruptures, after a period varying from a few days to several years. The blood escapes into the peritoneal cavity, the retroperitoneal connective tissue, the intestine, the pelvis of the kidney or the urethra, the ductus communis choledochus, the sheath of the psoas magnus, the vena cava inferior, the mesentery, the mesocolon, the gastro-hepatic omentum, or the spinal canal. Even the diaphragm may be perforated, rupture then occurring into the left pleura, lung, primary bronchus, or into the pericardium. The method of perforation presents interesting differences, according as rupture takes place into the peritoneal and pleural cavities, or upon a cutaneous or mucous surface. In the former case, the rupture is effected by a sudden tearing of the distended and atrophied serous structure, while, in the latter, gangrene of the cutis or of the mucous membrane is produced by protracted tension and compression. In the former case the hemorrhage is, almost unavoidably, sudden and profuse. In the latter, the aperture may be of small dimensions and partly occluded by thrombi. The fatal issue may thus be postponed, even for weeks, by the gradual formation of a diffuse aneurism from a slow escape of blood into the submucous or subcutaneous cellular tissue. Such diffuse aneurisms may even extend so far as beneath the iliac and pelvic fasciæ, or may penetrate between the layers of the mesentery and of the omenta.

Spontaneous cures are infrequently effected by processes described in the preceding article.

PHYSICAL SIGNS.—Small aneurisms, growing from the posterior aspect of the aorta and enlarging exclusively backward, may defy detection by any method of physical exploration. So soon, however, as an aneurism growing from the anterior aortic wall has attained a moderate size, it usually presents on inspection, provided that the abdominal parietes be sufficiently relaxed and the intestines undistended, a visible impulse in the course of the abdominal aorta. If the aneurism be of large dimensions, the abdominal respiratory movements may be decreased, and those of the thorax perceptibly augmented. Jaccoud emphasizes the fact that the tumor, being immobile, is unaffected by the respiratory movements. On *palpation* an immobile, elastic tumor, pulsating, according to Sibson, in fifty-five per cent. of the cases, the impulse of which is systolic and expansile, is commonly detected in the epigastrium, to the left of the median line, but may project to the right side, or even be found in the hypochondriac, the iliac, or the lumbar region. A slight diastolic impulse may rarely be observed. The tumor is ordinarily smooth and compressible, but sometimes nodular, unyielding, and even non-expansile. In the latter case it may be assumed that the aneurismal walls are very thick, that abundant coagula and fibrous laminæ are present within the sac, or that the aperture communicating with the artery is occluded. The pulsations in the arteries of the lower extremities are feeble and somewhat retarded. Pressure applied to the artery *above* the tumor diminishes the size of the latter and arrests the impulse, but if made *below*, augments the tumor's dimensions and increases its impulse. Applied directly to the tumor, pressure may occasion its collapse, or may be prevented from producing this result by too great solidity and density of the fibrinous laminæ within the sac. A thrill or vibratory fremitus is occasionally perceptible over the tumor, but is oftener absent. On *auscultation* a murmur, blowing or musical, post-systolic, always single, according to Luton and Walshe, and not transmitted beyond the tumor, is usually perceptible anteriorly, rarely posteriorly, if the recumbent position be maintained. Quincke states that the murmur may sometimes be heard below the tumor, or in the lumbar region. The murmur is occasioned by the passage of blood into the sac. If the aperture of the latter be rough, the sound is rasping or musical, but it is soft and blowing if the opening be smooth. Over aneurisms enlarging only in a backward direction the murmur is perceived exclusively behind, beside the vertebral spines. In other cases it may be audible both anteriorly and posteriorly. Should the patient assume the erect posture, the murmur almost invariably disappears; but it may, exceptionally, persist in that position, or even be *only* audible while the patient is standing or sitting. The disappearance of the murmur in the erect posture is explained by the augmented tension of the aneurismal walls, occasioned by increased hydrostatic pressure, and by the consequent limitation of the quantity of blood finding ingress to the sac. No safe inference can be drawn, from the intensity or the quality of the murmur, regarding the size or the stage of development reached by the aneurism. Many observers agree that the second cardiac sound is sometimes heard, either in front or behind, after the usual post-systolic murmur.

On *percussion* flatness or dulness may be found over the tumor, but these signs are inconstant, owing to the frequent occurrence of gastric and intestinal tympanites, and to the varying rigidity of the abdominal parietes.

RATIONAL SYMPTOMS.—These are either local and due to pressure, or general and dependent upon asthenia. The most constant localized symptom is pain, which is very variable in character, in position, and in intensity. It presents itself in two different varieties, the former constant, the latter paroxysmal. The former variety is variously defined as dull, boring, throbbing, or teasing; the latter as sharp, lancinating, and exhausting. The sites of the former are the epigastrium, the dorsal and the lumbar regions; while the latter, originating in these locations, radiates into the hypochondria, the inguinal regions, the hips, the testicles, down the anterior or posterior aspect of the thighs, and even upward into the thorax or the shoulders. The pains are the result of pressure exerted by the aneurism upon the spinal nerves, at their exit from the intervertebral foramina, and upon the solar plexus. There is no constant and necessary connection between erosion of the vertebræ and the occurrence of pain, since many cases are on record of pain from pressure on the nerves unattended by erosion, and, on the other hand, of extensive erosion without the slightest pain. Erosion is, however, of tolerably constant occurrence. Pains due to pressure on the nerves will naturally be produced, as a rule, by aneurisms growing from the posterior aspect of the aorta, and those referable to interference with the semilunar ganglia by tumors developing from the anterior aortic wall. The intensity of the pain varies from a vague and scarcely perceptible sense of discomfort to the most excruciating torture. The lancinating pains usually surpass the fixed ones in point of severity, and both varieties are intensified as the disease advances. The fixed pain is constant, and is greatly aggravated by pressure over the painful spot, by sudden exertions, or even by trifling movements, by eating and drinking, and by the assumption of the supine or of the erect position. Relief is afforded by the assumption of the abdominal decubitus, by flexion of the spinal column, and rarely by pressure. The duration of the paroxysmal neuralgic pains varies from a few moments to several hours. Their accession is abrupt and their subsidence equally so. After their cessation the patient is left in a comparatively painless, but exceedingly asthenic condition. In a few recorded cases pain has been absolutely wanting.

The symptoms other than pain, resulting from pressure, are occasioned by direct interference with the functions of organs adjacent to the aneurismal tumors. Nausea, emesis, cardialgia, pyrosis, dysphagia, anorexia, tympanites, eructations, gastralgia and enteralgia, constipation, obstipation, and diarrhœa may be incident to pressure upon the stomach, œsophagus, intestine, or pancreas, and are probably in part due to interference with the sympathetic and pneumogastric nerves.

Digestive disturbances are less pronounced in connection with aneurisms growing from the posterior aortic wall. Pressure upon the liver, the hepatic duct, or the ductus communis choledochus may lead to icterus. Dyspnœa is incident to upward displacement of the diaphragm and to consequent encroachment upon the intra-thoracic space. Irregular cardiac action attends displacement of the heart or involvement of the pericardium. Cough may be excited by irritation and inflammation of the pleura and of the pulmonary parenchyma. Compression of the renal vessels produces functional or structural disease of the kidneys. Œdema of the lower extremities is a rare symptom, due to pressure upon the vena cava inferior, which vessel, from its position, often escapes injury. Ascites results from pressure upon, or obliteration of, the portal vein, but is an exceedingly infrequent symptom. A subnormal temperature of the lower limbs, with hyperæsthesia, formication, numbness, anæsthesia, and final paralysis, are the occasional effects of pressure upon the spinal cord and nerves. Renal and biliary colic may proceed from pressure upon the ureter and the biliary passage. Irritation of the psoas magnus excites symptoms similar to those of psoas or lumbar abscess.

The GENERAL SYMPTOMS consist in gradual depreciation of the vital powers by reason of the pain, insomnia, malnutrition, and impaired innervation. Extreme emaciation is sometimes observed, and may, in the absence of other adequate causes, be referred to compression or obliteration of the receptaculum chyli or of the thoracic duct. Death from exhaustion occasionally happens, but the usual termination is by rupture and hemorrhage. The symptoms of rupture are either those of sudden collapse or, if the hemorrhage be of gradual occurrence, those of intra-abdominal or intra-thoracic diffused aneurism and of progressive asthenia, possibly complicated by peritoni-

tis or attended by recurrent hæmoptysis, hæmatemesis, hæmaturia, or melæna.

ANEURISMS OF BRANCHES OF THE ABDOMINAL AORTA.—Owing to their rarity and to their comparatively small size, aneurisms of the abdominal branches of the aorta usually present so few symptoms as to escape observation or to elude diagnosis. The branches most frequently the seat of aneurisms are, according to Lebert, the iliacs, the cœliac axis and its divisions, the superior mesenterics, and the renals, in the order named. The symptoms and signs of these tumors are similar to those of aortic aneurisms. Aneurisms of the superior mesenterics and of the cœliac axis are, however, *mobile*, and usually occasion no retardation or diminution in the pulsation of the femoral arteries. Renal aneurism is specially liable to interfere, by pressure on the ureter and the renal vein, with the functions of the kidney, and hepatic aneurisms often lead to jaundice. Statistical data regarding the relative frequency of ascites, in cases of hepatic aneurisms, are lacking.

DIFFERENTIAL DIAGNOSIS.—Abdominal aneurisms must be differentiated, first, from abdominal tumors to which the aortic pulsation is communicated. Those tumors most likely to be mistaken for aneurisms are carcinoma of the stomach, pancreas, omentum, intestine, and liver, fecal tumors, gall stones or foreign bodies impacted in the intestine, enlarged lumbar and mesenteric glands, renal tumors, as hydro- or pyonephrosis, floating kidney, ovarian or uterine tumors, enlarged or displaced left lobe of the liver, and encysted peritoneal exudations. Not only may these tumors receive an impulse from the aorta but they may produce a murmur by pressure upon that vessel. The character of their impulse is, however, heaving or lifting and not expansile, and it, as well as the murmur, can ordinarily be made to disappear by placing the patient upon his hands and knees, when the tumor gravitates away from the artery The tumors in question are, as a rule, movable, while aneurisms of the aorta are immovable. Aneurisms of the aorta's branches may be mobile, but their murmur persists after displacement of the aneurisms from their original position, which is not true of the other tumors under consideration. The latter are, moreover, of firmer consistency, and are more frequently accompanied by varicose abdominal veins, by ascites, or by œdema of the legs, and, if carcinomatous or tuberculous, by a more decided cachexia.

Secondly, from lumbar and psoas abscesses, which simulate aneurisms chiefly by causing dorsal pain and spinal curvature, but which are unattended by impulse, thrill, or murmur.

Thirdly, from various neuralgic affections, as renal and biliary calculus, gastralgia, enteralgia, neuralgia of the testicle, lead colic, lumbago, muscular rheumatism, and sciatica, the exclusion of which must depend on thorough physical exploration.

Fourthly, from abnormally forcible pulsation of the aorta. This is not accompanied by pain, thrill, dulness, murmur (unless the latter be excited by pressure with the stethoscope), or expansile impulse, and is often developed in connection with dyspepsia, profuse hemorrhage, or hysteria in young, chlorotic women. This form of pulsation is not localized but propagated through the entire aorta and its chief branches, nor is it attended by abnormal dilatation of the artery. It may be produced either by temporarily increased force of the systole, due to excitement, or by hypertrophy of the left ventricle. It is sometimes observed in aged women, with relaxed or retracted abdominal walls, and with lessened arterial pressure incident to spanæmia.

Fifthly, from pulsatile, malignant, renal, hepatic, or pancreatic tumors which, though very difficult to diagnosticate, are accompanied by more marked cachexia than is generally present in cases of aneurism.

Sixthly, from abscesses or furuncles of the abdominal walls, the superficial and inflammatory character of which is easily demonstrated.

PROGNOSIS.—Abdominal aneurism is an exceedingly grave disease. While cures, either spontaneous or due to therapeutical interference, are sometimes observed, the overwhelming majority of cases terminate fatally within a period varying from a few months to several years, either by rupture, which occurs, according to Sibson, in seventy-seven per cent. of all the cases, or by progressive exhaustion. The prognosis is unfavorably affected by the coexistence of any chronic disease, particularly of emphysema, phthisis, or asthma, which accelerate the progress of the aneurism by the repeated succussion movements incident to paroxysms of coughing. In some instances, all symptoms may disappear, only to reappear after a variable interval. In other cases the disease may remain latent until shortly before its fatal termination.

TREATMENT.—This is either palliative or curative. The former aims at the mitigation of suffering caused by pressure or by complicating diseases, the latter at obliteration of the aneurismal sac by the deposition of laminated fibrin. The means best adapted to the palliation of pain are chloroform and aconite, hot applications, leeching and cupping, employed at the seat of the aneurism, and, most potent of all, morphine hypodermically administered. Insomnia demands chloral and opiates.

The means employed to facilitate and hasten the deposition of fibrin within the sac relate to reduction of arterial tension, and to diminution of the rapidity of the blood current. Valsalva's method, based upon venesection and starvation, has justly been abandoned. The postural and dietetic treatment of Mr. Tufnell has yielded encouraging results. As an example of these we cite two abdominal aneurisms cured by Mr. Tufnell, after treatment protracted respectively thirty-seven and twenty-one days. In accordance with this method the patient is confined to the horizontal posture from eight to thirteen weeks, according to the progress made. No movement is allowed, and the diet is restricted to eight ounces of liquid and ten ounces of solids daily, the *menu* being as follows: For breakfast and supper, two ounces of wheaten bread and butter, with two ounces of milk, tea, or cocoa; for dinner, meat three ounces, potatoes or bread three ounces, and water or claret four ounces. Laxatives are daily used. The probably insurmountable difficulty attending this method consists in the physician's inability to secure the patient sufficient co-operation in so protracted and fatiguing a treatment. Better co-operation and greater success may be expected if the treatment merely embrace the limitation of physical exertion within proper bounds, the employment of nourishing but unstimulating aliments and drinks, attention to the bowels, and the use of aconite, or of hydrocyanic acid, to secure regular and moderate cardiac action. Alcoholics may, however, be sparingly used in case of evident cardiac weakness. Iodide of potassium, in doses of fifteen to twenty grains, thrice daily, is strongly recommended by Doctors Balfour, A. Flint, and Bouillaud. Its beneficial effect is attributable to depression of the heart's action and to consequent diminution of vascular tension. Ergot, hypodermically, is advocated by von Langenbeck on the same theoretical grounds.

Proximal or distal compression of the abdominal aorta for the cure of abdominal aneurism, first suggested by Mr. Holmes, finds many warm advocates and boasts a number of successful results. The preliminary treatment consists in evacuation of the bowel and in the expulsion of flatus. Anæsthesia is essential. The instrument employed is the abdominal tourniquet, and sufficient pressure is applied completely to arrest the blood current in the aneurism. Mr. Murray recommends that the treatment be conducted as follows:

1. That pressure be applied for four hours. If *no* effect be then apparent, the first attempt is abandoned. If *any* diminution of impulse be manifest, the tourniquet is applied for another hour.

2. In the event of failure, at the first operation, another trial is made, after a few days, and pressure maintained for from six to eight hours.

3. If the second attempt fail, pressure may be con-

tinued, at the third operation, twelve hours, but it must be instantly removed if inflammation or shock supervene.
William H. Flint.

ANEURISM, THORACIC.*—In this article no attempt is made to discuss in detail the pathology of aneurism in general, as that will be found under its proper heading. It is intended rather to present in as condensed a form as possible the principal points bearing upon the diagnosis and treatment of this particular form of the disease.

ETIOLOGY AND PATHOLOGY.—In seeking for the causes which are operative in the production of thoracic, as of other forms of aneurism, we must bear in mind the two main conditions which are in themselves the most powerful agents, viz., a weakened condition of the arterial walls, and increased blood pressure. All circumstances, therefore, which tend to bring about one or other of these disordered states tend to induce the formation of an aneurism. Probably one alone will sometimes be sufficient, but if both together unite, the necessary consequences are rendered still more certain.

The constitutional conditions which are known to predispose to atheroma and, therefore, to aneurism are hereditary predisposition, gout, rheumatism, kidney disease, syphilis, and alcoholism. To these must also be added strain and laborious occupations involving repeated (though less severe) straining efforts. It is sudden increase in the blood pressure, however, which is much more liable to induce aneurism than prolonged exposure to a moderate degree of increased tension, as seen in Bright's disease. It has, moreover, been fully proven that tight clothing, as in soldiers, acts injuriously in intensifying the effect of any straining effort. Occupation, therefore, is a direct exciting cause of thoracic aneurism. Any kind of work which, besides being laborious, involves at times powerful muscular efforts, must be looked upon as a factor—perhaps often the most important factor—in the etiology. Soldiers, as above noted, are notoriously prone to be affected by it, being subject to a combination of injurious influences. Prostitutes, also, frequently have aneurism of the chest from being affected with syphilis and leading lives of dissipation and excitement, highly provocative of muscular disturbances. According to Hare's statistical results a history of trauma is frequent in cases of aneurism. It is well established that one or more of the coats of a healthy artery may be ruptured by sudden strain or direct violence, whilst in vessels weakened by sclerotic changes, syphilitic or otherwise, such an accident is more apt to occur. An interesting case of this character is quoted by Gairdner in Allbutt's "System," together with a full discussion of the whole subject.

AGE.—Aneurism of the aorta may occur at any age, but it is especially common at the more advanced periods of middle life—between forty and fifty; but it is not infrequent between thirty and forty. Very few cases have been observed below twenty. The disease, although rare, is not unknown in children, in whom a syphilitic origin is almost invariable. The arteries of young persons are sound and will bear a sudden strain without injury. Old people very commonly have atheromatous arteries, but in them the circulation is weaker, strain is rare, and thus they seldom suffer from aneurism.

SEX.—Men are much more liable to aneurism than women. According to Dr. Peacock, from two-thirds to four-fifths of the cases of circumscribed aneurism occur in males, while dissecting aneurism makes its appearance in the two sexes with equal frequency. The difference is, no doubt, to be accounted for from the fact that men are much more exposed to the efficient promoting causes, viz., strain, laborious occupations, syphilis, and intemperance.

SYMPTOMATOLOGY.—The mere existence of a dilatation at some part of the aorta is not necessarily accompanied by manifestations of disordered function or local distress (symptoms). Unless, therefore, it mechanically interferes with neighboring parts, it may continue even for a long time unsuspected. The occurrence, then, of symptoms which will indicate the existence of thoracic aneurism, depends more upon the exact situation of the tumor than upon any other circumstance. The symptoms also will present wonderful variety in accordance with the varying locality and direction of the expansion of the growth. The clinical history of these patients previous to the development of the characteristic symptoms is often extremely indefinite. It is quite common to find a man seeking advice for a loss of voice or a harsh cough, or a thoracic pain, found to be due to an aneurism of some standing, and yet he will give an account of having enjoyed excellent health in every respect until (perhaps quite recently) these symptoms attracted his attention. Again, sometimes a quick pain, with palpitation and breathlessness, has been observed at some remote period, to be followed later on by other symptoms of intra-thoracic disorder. Or, some laryngeal or bronchial symptoms may have been coming on imperceptibly for a long time past. In many cases, belonging to one of the above types, of men above middle age, whose general health and nutrition remain unimpaired, suspicion of aneurism may very reasonably be entertained. Deep-seated aneurisms may be entirely latent, presenting no evidence of their existence by either symptoms or physical signs. The comparative frequency of such cases is now being very generally recognized.

The symptoms of thoracic aneurism, therefore, are mainly the symptoms of intra-thoracic pressure, and mostly differ in no respect from those produced by tumors of different nature in the same situation. The symptoms consist of the manifestations by which we can recognize displacement of lung substance, compression of the main or secondary air tubes, irritation or destruction of nerves, obliteration of venous channels, obstruction of the œsophageal tube, or erosion of some of the bony structures.

The principal symptoms of intra-thoracic pressure may be thus enumerated—pain, dyspnœa, altered voice, cough, stridor, headache, and disordered vision, and lastly, paraplegia.

The *pain* of thoracic aneurism is a most frequent symptom, but very variable as to its character, degree, and situation. In not a few cases pain of some kind will be the first indication of existing disorder. Early pain is usually of a somewhat lancinating nature, and is suggestive of neuralgia. It is often complained of as darting across some region of the chest or along certain nerves to distant parts. When the aneurism, for example, is seated in or near the innominate artery, the pain is often referred to the back of the neck on the right side and behind the right ear; when it is seated in the transverse arch, the pain may be across the top of the chest and down perhaps the entire length of one arm. Pains of this kind should always prompt a search for internal aneurism. Later on in the complaint the pain is likely to be of a steady, wearing kind, and referred to some fixed spot, probably deep in the chest. Aneurisms pressing backward against the vertebral column and the spinal nerves emerging therefrom have two special forms of pain connected with them: either a persistent boring pain experienced in some particular part of the spinal column, or a definite intercostal neuralgia, having a distributive, intermittent character, and tender spots often unusually well marked. There is sometimes pain of a real anginoid character, accompanied by a sense of tightness in the chest, but it is very seldom that attacks of true angina, with the typical features of this complaint, are witnessed. Pressure on the phrenic nerve has been found sometimes to be accompanied by a painful feeling of constriction round the lower part of the thorax, together with dyspnœa and singultus, from disturbed innervation of the diaphragm.

Dyspnœa is a very frequent symptom, and is of varying character and degree in accordance with the cause to which it may be due. It may arise from compression of

* As a friend and pupil of the late Dr. Ross I have been requested to revise this article.—F. G. Finley.

a portion of the pulmonary structures, from pressure upon the trachea, upon a main bronchus, or upon the pneumogastric trunk or one of the recurrent nerves. An aneurism must have attained to a considerable size before it can shut off a portion of a lung sufficient to produce decided dyspnœa. Shortness of breath, therefore, will not be much complained of in the early stages, unless the tumor interfere with some of the other structures just named. Compression of the trachea commonly occurs from aneurisms of the arch, and the dyspnœa will be observed to exist both in inspiration and in expiration. It is accompanied by enfeeblement of the respiratory murmur in both lungs, and the laryngoscope shows the mechanism of the vocal cords to be normal. Under favorable conditions a skilled observer can detect the narrowed lumen of the trachea by the laryngoscopic mirror, and in some instances can even observe pulsation transmitted from the aneurism at the point of pressure. Standing beside such a patient, it is quite usual to hear a rough, raucous sound of peculiar calibre accompanying both inspiration and expiration, especially when these acts are performed somewhat forcibly. The dyspnœa here, as in the last-mentioned form, is very markedly increased by even slight exertion, the chief reason, no doubt, being that the tumor, being expansile, the increased heart's action expands it, and causes it to compress the elastic tube more firmly. In exceptional cases of tracheal compression, paroxysms of intense dyspnœa may be occasionally witnessed, and that without direct involvement of any of the important nerves. Attacks of this character are apt to come on from exertion or emotional disturbance, and are attributed by Bristowe to more or less complete obstruction of the trachea by a plug of mucus. Position will often relieve the respiratory distress considerably, and patients very frequently, of their own accord, rest or sleep, leaning the chest well forward to take off the pressure from the windpipe. If a main bronchus be compressed (and it is most often the left), the dyspnœa is not likely to be so great, and enfeebled breathing is found in the corresponding lung. It has long been recognized that pressure upon the important nerves supplying the muscles of the larynx which pass through the chest will cause dyspnœa, and that, very often, of the most intense kind. Here the striking feature is dyspnœa *in paroxysms*. There may be periods of comparative calm, during which there is only a moderate shortness of breath on making some exertion, but suddenly, with or without any exciting cause, severe suffocative dyspnœa sets in, and in some cases actually proves fatal. This result may be brought about either by the compression or involvement of a pneumogastric nerve or a recurrent laryngeal nerve. Sometimes nerves of both sides are implicated. Owing to its situation in relation to the aneurism, the nerve of the left side is more often affected than that of the right. When the latter is involved, it is generally from its being disturbed by the dragging of a tumor upon the root of the right subclavian artery. It is held by some that this form of dyspnœa may be brought about either by spasm of the muscles supplied by the recurrent nerve or by their paralysis. Pressure, it is said, will either irritate or destroy a nerve. Irritation will cause spasm, destruction, paralysis. There does not, however, seem to be any reliable evidence of the occurrence of spasm as a cause of dyspnœa; while, on the other hand, whenever decided laryngeal symptoms are observed from intra-thoracic pressure, the laryngoscope nearly always shows the existence of paralysis in a greater or less degree. Unilateral paralysis may exist for a long time without marked dyspnœa, but, if the opposite muscles become affected, the liability to paroxysmal attacks becomes developed, the flaccid cords are sucked together by the inspiratory effort, and a suffocative condition is induced. Why does this occur in paroxysms? It may be that a rapid temporary enlargement of the tumor occurs (from exertion, etc.), and that this causes increased pressure, as a result of which the paralysis may be rendered *complete*; or it may be that, from incomplete coughing efforts, mucus collects in the glottis, and forms a complete barrier in the already partially obstructed glottic opening. A rare form of dyspnœa in aneurismal patients consists in a simulation of ordinary asthma. I have seen one such case in a young woman in which the picture presented was exactly that of a common attack of spasmodic asthma.

Alterations of voice are observed only when the tumor presses upon one of the recurrent nerves, or upon a pneumogastric trunk. The changes in the voice consist mainly in diminution of its power and clearness in varying degree, together with hoarseness and sometimes a squeaky or high-pitched tone. The loss of voice may come on quite suddenly, and ultimately complete aphonia may result. These laryngeal symptoms may be among the very first complained of, thus simulating catarrhal laryngitis, for which this condition has frequently been mistaken. Laryngoscopic examination almost invariably shows deficient abduction of a vocal cord (more frequently the left). If the paralysis be incomplete, the affected cord is seen, on phonation, to fail to reach the median line, and thus an open space is left between the two. It if be complete, the paralyzed band remains almost, if not quite, stationary, and the healthy cord is seen to move rapidly across the median line until it approaches its fellow of the opposite side.

Stridor is specially noticed when an aneurismal tumor presses upon the trachea or one of the main bronchi. It differs altogether from the stridulous respiratory sounds heard in cases of laryngeal disease, and is distinguished also from them in that the ordinary speaking voice remains unimpaired. The stridor is usually a rough, low-pitched, growling sound, accompanying both inspiration and expiration, and giving the impression of originating deep within the chest. It is markedly increased by full breathing. This is the so-called "stridor from below" of the older authors.

Cough very commonly occurs during the course of a thoracic aneurism. It is produced mainly by the irritation from pressure of the pulmonary and laryngeal nerves, and is often very frequent and distressing. If there be laryngeal paralysis the cough will probably be husky, and even suppressed. When tracheal pressure with stridor exists, the cough likewise becomes loud, rough, and clanging in character. The expectoration at first is very small in quantity—in fact it may be so throughout; but when there has been much pulmonary irritation, or when a tracheo-bronchial catarrh has been set up, large quantities of purulent expectoration may be got rid of. Blood sometimes appears in the sputum, and must always be looked upon as a sign of impending danger.

Dysphagia is a symptom more often seen in connection with other forms of intra-thoracic tumor than with aneurism. It has also been clearly proven that an aneurism may have exerted considerable pressure upon the œsophagus and yet no resulting dysphagia have been observed. Certain peculiarities in œsophageal obstruction due to aneurism (as compared with that which results from other tumors or from organic stricture) are these: that it is variable—perhaps at one time of day nothing can be swallowed, and again, later on, fluids or semi-solids pass with comparative ease; and, secondly, it is altered by position—the patient may be able, by removing the weight of the tumor on leaning well forward, to swallow fairly well, while the same thing is impossible in the recumbent position.

Engorgement of the vena cava and its branches, from pressure of the sac upon this great trunk or upon one of the innominate veins, occurs pretty frequently. It is indicated in the lesser degrees by undue fulness of certain of the superficial veins of the neck, shoulder, and front of the chest. In an extreme degree the appearances produced are very striking. The face is purple and congested, the eyes are suffused, the superficial veins greatly distended with blood and mostly tortuous. The tissues at the root of the neck become infiltrated and present a soft, swollen appearance, obliterating more or less the hollow above the clavicle. The congestion of the internal veins, which must simultaneously occur, causes these

patients to suffer from headache and often from great drowsiness, and death may take place in a comatose condition. Pressure on the brachial veins will cause swelling of the corresponding arm.

Difference in the Size of the Pupils.—The anterior roots of the spinal nerves from the sixth cervical to the sixth dorsal (according to Brown-Séquard to the ninth or tenth dorsal) supply to the cervical sympathetic filaments which pass to the iris. When an aneurism presses upon these nerves, then ocular symptoms are observed, more or less marked according to the degree of the pressure. If the pressure is slight, then irritation only is produced, and, as a consequence, there is dilatation of the corresponding pupil. If the pressure is considerable, then paralysis is produced, and we find permanent contraction of that pupil. With reference to this symptom, it must be developed to a decided degree before any reliance can be placed upon it, because the slighter differences in size between the two pupils are quite commonly observed in healthy persons. Even when this symptom is clearly made out its importance is not great from a diagnostic point of view, for there are generally then present many more reliable indications of the disease. But it can be used as one means to assist in enabling us to locate more precisely the seat of the tumor.

Emaciation is very often wanting, and persons with large tumors may remain quite well nourished. Considerable emaciation is, however, often seen arising from coincident weakness of the digestion, want of exercise, and continued suffering. Marked wasting of the tissues has, in rare cases, been traced to pressure upon the thoracic duct, and again, although it develops less rapidly, to pressure upon the œsophagus and to inanition.

Such are the chief symptoms of thoracic aneurism, which are the result of the intra-thoracic pressure which it must sooner or later produce, and it is to them we must generally look for aid in establishing a diagnosis. But there are others which must be mentioned. It sometimes happens that the objective signs of aneurism may be present while subjective symptoms are entirely wanting. But the contrary is more generally true. Various complaints will be made before the existence of their cause can be satisfactorily made out. Much, of course, will depend upon the situation of the tumor. Patients often first experience pains in the chest, the different characters of which have been already alluded to. As the tumor increases in size these painful sensations may be modified in various ways by the occurrence of complicating inflammations of surrounding parts, and especially of the pleura. There may also be a distinct sensation of throbbing or pulsation in the chest in the region of the aneurism. Palpitation of the heart and tightness in the chest are often associated with these. The patients themselves may also observe that alterations of position have an effect in increasing or diminishing their discomfort. Then dyspnœa of some kind is likely to occur and to be followed by dysphagia, neuralgias, pareses, or actual paralysis (perhaps only formication or numbness), some anæmia, diminution of strength, and sometimes œdema. An aneurism of the chest may thus cause death by a gradual process. Less commonly we observe continuous increase in the tumor until it finally ruptures and death ensues, either directly from hemorrhage or indirectly from the effects of the effusion of blood upon some vital organ. Rupture is generally associated with enormous hemorrhage, which is inevitably fatal in a few minutes or seconds. It does happen, however, that smaller bleedings occasionally make their appearance for some time (it may be for only a day or even for a longer time) previous to the final gush. In the case of a gentleman, under the care of the writer, who died of this disease a short time ago, small quantities (a few ounces) of bright arterial blood were brought up for more than twenty-four hours preceding the actually sudden end. In this case the aneurism broke into the substance of the lung, and evidently had leaked into a small bronchus during the time mentioned. The final rupture took place into the left main bronchus, and was accompanied by a great spirt of fluid blood, and followed by instant death. Hæmoptyses sometimes occur at long intervals (years) in aneurisms, generally from associated pulmonary congestions.

When rupture takes place, it may be accompanied by a sense of tearing within the chest, and if the blood does not appear externally with cough or efforts of vomiting (through the trachea or through the œsophagus), then it will be recognized by the accompanying pallor and syncope, with failure or extinction of the pulse. Internal rupture takes place most frequently into the pericardium, and is almost always immediately fatal, although in a case quoted by Kelynack the patient lived for four hours. Pepper and Griffith have published a case of rupture into the superior vena cava, and they have collected twenty-seven other instances, whilst Fränkel has recently recorded two such accidents recognized during life. The symptoms are dyspnœa, followed by slight proptosis, and by œdema and cyanosis of the face, neck, upper part of the thorax and arms. There is frequently a continuous murmur, louder during systole and produced by the passage of blood from the aorta into the vena cava. Death in such cases is not necessarily immediate, and has been postponed for several weeks or months after the occurrence of the rupture. Escape into a pleural cavity is common, and is marked by severe pain and dyspnœa, and by the presence of the physical signs of effused fluid. I have seen one case of rupture into the pulmonary artery when the symptoms consisted of sudden pain, collapse, want of pulse, and tumultuous action of the heart for about two hours before death. External rupture is comparatively rare. If such a rupture is impending, the fact will be recognized by the commencing lividity and finally gangrenous appearance of the tensest portion of the projecting tumor. This accident is sometimes induced by straining or falling, or by rough handling.

Physical Signs.—The foregoing symptoms (which are mainly those of excentric pressure) are indicative of intra-thoracic tumor of some kind, but cannot indicate aneurism specially. On observing any combination of them, we must turn to the physical signs to determine the character of the tumor—they are, of the two, therefore, the more important; and both together will, in the majority of cases, enable the physician to arrive at a positive diagnosis. These physical signs are derived both directly from the tumor itself and indirectly from an examination of the neighboring organs which may have been pressed upon, displaced, or otherwise interfered with by the encroaching tumor. The signs, as regards the aneurism, will evidently depend mainly upon its size and its exact position, especially as regards the surface of the chest.

Inspection will readily demonstrate the existence of any distinct bulging of the parietes of the chest. This may be only a slight or ill-defined elevation of a circumscribed area, or it may be a tumor of some magnitude. The elevated part, moreover, is seen to pulsate (almost) synchronously with the apex of the heart. The situation of the pulsating prominence depends upon the portion of the aorta involved, and the direction in which it has been tending. Aneurisms of the ascending arch are most commonly seen in the second or third interspace of the right side. Those of the descending aorta will most commonly reach the surface on the posterior or lateral wall of the chest. The skin over the prominence is usually healthy, except when the external tumor is large, when it may be red or livid. There may be no elevation from the general surface, the eye only detecting a pulsating spot similar to that over the cardiac apex. In the absence of these more characteristic appearances, if the front of the chest be carefully examined while the patient stands sideways to the observer, a more or less distinct systolic heaving of the chest wall can be noticed, especially when the respiration is withheld. This indicates usually an aneurism of considerable size and deeply seated. If the heart be displaced, this fact can also be determined by the altered position of the apex beat.

Palpation of the chest is of service only when the tumor sufficiently approaches the chest walls. Local ful-

ness or bulging can be appreciated, pulsation can be located, and the force of the impulse measured. Frémissement, or thrill, systolic in rhythm, can also not infrequently be felt, perhaps over the entire area covering the tumor; and following this, sometimes a diastolic shock may be recognized. In obscure cases, in which a deep-seated aneurism may be suspected, the bimanual method of examination may prove of great service. The patient's chest is firmly grasped between the two extended hands laid flat upon the surface. By this means a diffused sense of expansion will be experienced which is extremely significant and can only be ascertained in this way. The supra-sternal notch should also be explored. The patient's head being bent forward to relax the sterno-mastoid muscles, one or two fingers are pressed deeply into the fossa and beneath the manubrium sterni, when pulsation or thrill communicated from the transverse portion of the arch can be distinctly perceived. Another physical sign of very great diagnostic importance, and one which is also to be obtained by the educated sense of touch, is what is now known under the term "tracheal tugging," or Oliver's sign. It is but quite lately that attention has been directed to this method of examination, and it is only now that its value is being realized. To examine for this sign proceed as follows: Let the patient be seated upright and with the head well thrown back, in order to put the windpipe upon the stretch. Then with the finger and thumb of the right hand grasp the cricoid cartilage or the lower border of the thyroid, and make steady pressure upward. If a deep-seated aneurism be present which impinges at all upon the trachea or one of its principal divisions, then a very distinct and unmistakable *tugging downward* will be felt with each systole of the heart. When the heart is acting strongly, or when aortic incompetence is present, considerable rhythmical pulsation may be communicated to the fingers from the adjacent carotids, but with a little care this cannot be mistaken for the tugging directly downward above described. I have observed a considerable number of cases of thoracic aneurism, cardiac and other thoracic diseases with reference to this sign, and I have never observed it produced by any other condition but aneurism. In one case, which I saw in consultation, there seemed clear evidence of an aneurism of the transverse arch, and the presence of stridor and paroxysmal dyspnœa showed its interference with the trachea and nerves. No tugging could be felt. The autopsy, however, showed that the tumor was completely filled with firm laminated fibrin, and its pulsatile character was lost. Except in cases of this kind (which must be of pretty long standing) tracheal tugging may always be looked for in central aneurisms of the chest. This sign was attributed by MacDonnell to pulsation transmitted downward to the left bronchus. It may, however, be present in any instance in which the aneurism is adherent to the trachea, and Fraenkel has seen it in an aneurism of the ascending aorta in which firm adhesions were present between it and the trachea. It is conceivable that a vascular pulsating tumor might give rise to this sign, but hitherto no well-authenticated case of solid tumor has been published with tracheal tugging. Care must be taken to distinguish a slight downward pulsation, often felt in healthy necks, from true tugging. Hall has recently described a diastolic shock following the systolic tracheal tug.

Percussion elicits a flat note over the area throughout which the aneurism is in contact with the chest wall. This area, of course, may give no idea of the actual size of the aneurism, for its principal bulk may be buried beneath healthy lung tissue. A modified dulness may sometimes be found for some distance around the flat region. It is often impossible to separate the dulness of the aneurism from that over solid organs, the heart, liver, etc. Of course, if the tumor be entirely deep-seated, the percussion may be everywhere normal. If also the lungs be emphysematous, no information can be obtained from percussion.

Auscultation over an aneurism of the aorta reveals of necessity only a systolic and a diastolic sound, such as we hear over the vessel itself. The systolic sound, however, may be modified, and is sometimes accompanied by murmur. The modification consists generally in loudness, while, at the same time, a sense of impulse is conveyed, the so-called *bruit de choc*. The diastolic sound is communicated from the aortic valves, any increase in their tension intensifying the second sound over the aneurism. It is always accentuated when the diastolic shock is perceptible on palpation. Systolic murmurs are of tolerably frequent occurrence. They are probably produced in one of two ways: either by sudden alteration in the calibre of the vessel (causing fluid waves or eddies) or by the vibrations produced by contained coagula or irregularities in the course of the blood current.

The systolic murmur of an aneurism is generally blowing in character, but sometimes possesses a decided musical or "cooing" quality. Its seat of maximum intensity is likely to be the central part of the tumor, and it is not generally diffused to any very considerable distance from this. The significance of the murmur is derived from its seat of maximum intensity being away from that usually associated with valvular lesions, and from its being accompanied by a magnified second sound. Heard alone (*i.e.*, without accentuation of the second sound) a systolic murmur is rather indicative of some other condition than aneurism. Indeed, diastolic accentuation, if confined to some circumscribed dull area in the neighborhood of the aorta, is of more value than any murmur. Any murmurs generated at the aortic valves and orifice are likely to be transmitted through an aneurismal tumor as well. Often, therefore, double aortic murmurs are to be heard in this situation. Sometimes, however, similar to-and-fro sounds are generated within the sac itself, their origin being declared by their being much louder over the corresponding area than elsewhere, by being much more restricted to this region, and by not being at all necessarily associated with dilated hypertrophy of the left ventricle. A diastolic murmur alone may, exceptionally, be heard arising from an aneurism, and Gerhardt states that a diastolic murmur may sometimes be heard in the left supra-spinous area. Over the tumor the respiratory murmur is absent, but on passing just beyond the edges of this, the breathing sounds are heard, but generally of a somewhat bronchial character. In the same areas the voice will have a bronchial resonance, although decided bronchophony will not be found (or, at any rate, is rare).

The *pulse* in internal aneurism may, or may not, afford positive information. The arteries themselves are frequently in a diseased condition, fibroid or sclerotic, and may thus affect the pulse. The state of the heart will also have to be taken into account. If, however, the blood be flowing into an aneurism of considerable size, special alterations in the blood current, in the parts on the distal side of this, may be observed and delineated. The effect of the diverticulum is to act like the empty rubber ball in the ordinary syringe, *i.e.*, to make the current more even and steady and less spasmodic and jerky. When, therefore, a sphygmographic tracing is taken, the curve is found to differ from the normal one in accordance with this mechanism. The ascent of the systole is less abrupt, more gradual, and the descent also occurs without the same sharpness. The necessary result of this is to render the apex of the curve more rounded, less acute than that of the natural pulse. The larger the sac and the more distensible the walls, the better this kind of tracing is brought out, while fibrillation of the contents and stiffening of the walls tend to obscure these peculiarities and cause the tracing to resemble the normal curve. The value of these observations is greatest when we examine at the same time the corresponding artery of the opposite side, or else the same artery (or a branch of it) above the region of the suspected aneurism. It is not uncommon to find such a degree of difference between the pulses of the two sides as may be clearly recognized by the finger. The differences consist in delay of the pulse and in alteration in its volume. Delay of the pulse in the radial artery is a diagnostic sign upon

which too much stress must not be laid, and, indeed, it is very often absent. Diminution in the calibre of the radial pulse of one side is important as an additional point of evidence in a case of suspected thoracic aneurism. Its positive value is, however, detracted from by a consideration of the fact that the same thing is often seen from congenital peculiarity or from irregular distribution of the blood-vessels of that arm. The latter possibility should always be sought for, and a comparison made between the brachials of the two arms. The alteration in the volume of the pulse may be produced by twisting or distortion of the vessel, by dragging upon it by the advancing growth, or by partial or complete obliteration of the lumen by the entrance into it of detached fragments of fibrin. The only special distinguishing mark of embolism is the suddenness with which it is apt to occur.

Thoracic aneurism is very frequently associated with changes in the heart and in the circulation. Other neighboring organs also become physically altered by reason of the pressure, or other interference, to which they may have been subjected. These conditions can generally be recognized by physical examination. Under some conditions, an aneurism may be the direct cause of hypertrophy, but the heart may remain entirely unaffected, even in the case of large aneurisms of long standing, provided there be a sound condition of the aortic valves. As, however, atheroma is often the common cause of both aneurism and aortic valvular disease, the former is frequently found along with dilatation and hypertrophy of the left ventricle. This backward affection of the ventricle cannot, therefore, be used as an argument in favor of aneurism, nor can its absence be construed against it. Displacement of the heart is often seen. This is generally a downward displacement only, or with some inclination to the left. When the tumor affects the descending aorta, the heart is displaced forward. If incompetence of the aortic valves be present, as often occurs, its existence is recognized by the usual physical signs. The cause of the incompetence may be either atheroma, as above mentioned, or the altered calibre of the root of the aorta produced by the tumor, *i.e.*, relative incompetence with healthy valves near to which the expansion has begun. Tumors near the origin of the aorta are also liable to cause pericarditis. This occurrence has frequently been found post mortem, and is occasionally witnessed during life. Dr. Byrom Bramwell ("Diseases of the Heart and Thoracic Aorta," p. 714) says: "In any case of non-rheumatic pericarditis occurring after the age of forty, in which the cause of the pericarditis is obscure, I strongly suspect the presence of an aneurism." The same author suggests that aneurism in the same locality may account for certain cases in which pericarditis and angina pectoris have been observed at the same time. Pleurisy is a common complication, and must be looked for either from friction sounds or from the signs of liquid effusion. It occurs most often with aneurisms of the descending aorta. The existence of a pleurisy at the base of one lung, followed by prolonged pain in the same region, otherwise unaccounted for, will certainly sometimes lead us aright by suggesting aneurism.

If a main bronchus be compressed, the corresponding lung becomes comparatively airless, its circulation is impaired, and catarrhal conditions prevail. In consequence of this the following physical signs will be found, viz.: Moderate dulness on percussion and enfeebled respiration, with or without moist râles. In a few of these cases a whistling sound can be made out over the situation of the compressed tube.

Changes in the lungs are not uncommon in aneurism. Owing to the frequency with which the left bronchus is compressed these changes are much more frequent in the left than in the right lung. Fibroid changes with retraction, gangrene, and suppuration are seen and may even mask the primary disease. Constriction of the left bronchus by aneurismal pressure sometimes sets up bronchiectatic dilatation below the site of stricture. Such a condition is usually not recognized during life, but exceptionally symptoms and signs of bronchiectasis can be discovered.

We may now consider more particularly the chief symptoms and physical signs which indicate aneurism in the different parts of the thoracic aorta.

Aneurisms of the Root of the Aorta (*the Sinuses of Valsalva*).—Those aneurisms which spring from the very commencement of the aortic tube are not very uncommon. They are frequently entirely latent, but symptoms of pericarditis, or of angina pectoris, may occur. They are quite liable to cause aortic incompetence. Such tumors are very dangerous, as, before arriving at any great size, they are liable to rupture, especially into the pericardium. Dr. Bramwell figures (*op. cit.*, p. 720) a remarkable aneurism springing from this situation; it attained an enormous size, perforated the sternum, formed a large external projection, and finally ruptured through the integument.

Aneurisms of the Ascending Portion of the Arch.—In this region of the tube, dilatations, cylindrical or spindle-shaped, are most frequent, but saccular aneurisms also occur. The latter are then generally situated upon the right side of the aorta. In an early stage of dilatation we shall find altered pitch of the percussion note to the right of the sternal margin above the second rib, and the pulsation of the aorta becomes stronger and more perceptible above the sternum. As it increases, we get more decided dulness, extending to the right above the second rib. The first sound becomes dull and the second more forcible and clanging. A systolic murmur may then become developed in the same area, and this, from its seat of origin and want of diffusion, may be distinguished from a valvular murmur. Disease of the aortic valve frequently coexists. Aneurism in the ascending arch has a tendency to reach the surface of the chest, and can, therefore, generally be made out with ease by the physical signs. The locality where pulsation and bulging are most apt to be discovered is the neighborhood of the second costal cartilage of the right side. The edge of the sternum and one or two ribs become eroded, and the tumor, which may be of considerable size, projects. The pulse in the vessels on the right side will be small and delayed compared to that of the vessels on the left, if the innominate be involved. Compression of the superior cava or right innominate vein may happen, with resulting dilatation of the veins of the upper half of the body or right arm. The symptoms commonly complained of are pain and dyspnœa, perhaps cough. When the aneurism is of considerable size, numbness and weakness in the right arm may occur from pressure on the brachial plexus. The right bronchus may also be sometimes compressed. Rupture of an aneurism in this situation occurs most frequently into the right pleural sac, the pericardium, the lungs, or externally. In one of my own cases, already mentioned, rupture took place into the pulmonary artery.

Aneurisms of the Transverse Portion of the Arch.—These may be either spindle-shaped or, more commonly, saccular. As they occupy that portion of the arch of the aorta from which spring the great brachial and cephalic branches, the latter are quite frequently involved in the aneurismal growth. They are common, but somewhat less so than those of the ascending portion. Their situation is such that they, soon after attaining any size, necessarily impinge upon some of the important structures in the centre of the thorax, giving rise in consequence to decided evidences of intra-thoracic pressure. The presence of a pulsating tumor in this region will also cause easily recognized changes in the percussion of the sternum and its margins, and can further be detected by the sense of touch behind the manubrium. Aneurism in the transverse arch is therefore, as a rule, readily diagnosed except when the tumor is quite small. Sometimes, even before any other signs have developed, the aneurism may be discovered by means of the finger pressed well down behind the sternum in the jugular fossa. As the expansion of the aorta here increases it pushes aside the edges of the lungs, and dulness becomes well marked

over the first piece of the sternum, and to a variable distance on either side of this. Then a heaving prominence makes its appearance in the same region, and, following upon the absorption of the sternum and upper ribs, an external tumor becomes developed which may even reach a large size. The radial pulses of the two sides quite frequently differ in size and fail to beat with the usual synchronism. This sign is more often met with in aneurisms of the arch, because here the innominate and subclavian arteries are so apt to have their calibre interfered with by pressure, by twisting or dilatation, or by the entrance of coagula. The parts most liable to compression in these cases are the œsophagus, trachea, recurrent laryngeal nerve, and left innominate vein. If the concave border of the arch be also involved, the left bronchus is liable to be partially or wholly obliterated. The signs by which these various conditions can be recognized have been already considered. Rupture occurs into the trachea, the œsophagus, or the pleural cavity, or more rarely into the mediastinum, the pulmonary artery, or one of the large veins.

Aneurisms of the innominate artery alone are rare, but we oftener see tumors of the arch associated with more or less considerable dilatation of the innominate trunk. The enlargement will be found beneath the right sterno-clavicular articulation and inner part of the first rib, and it may extend into the neck beneath the sterno-mastoid muscle. In these situations we must look for the usual local signs, swelling, pulsation, and bruit. The latter may be heard up the carotid. The effect upon the distal arteries is generally well marked. The symptoms are chiefly pain, both local and more especially radiating up the right side of the neck and back of the head, sometimes down the right arm, with numbness; and if the tumor be larger, there will be signs of compression of the trachea or the œsophagus or an innominate vein. Cases sometimes arise in which it is extremely difficult to determine whether the disease is confined to the innominate artery or occupies as well a portion of the arch at the origin of this vessel. For instance, a man came under observation a short time ago at the Montreal General Hospital, with a strongly pulsating tumor rising out of the neck above the right sterno-clavicular articulation. Dr. Fenwick, whose patient he was, believed it to be purely innominate. Its strict limitation to the area near this vessel, the distinctness with which the cylindrical tumor could be defined by the examining finger, the interference with the pulsations in the radials, and the absence of all signs of swelling of the arch, as determined by most careful examination, all seemed to favor this conclusion. This opinion was confirmed at a consultation of several members of the staff, and it was decided to recommend treatment by distal ligature. This the patient refused to submit to, and was discharged. He subsequently died suddenly, while running, from rupture into the pericardium of a small aortic dilatation just above the valves. The aneurism in question was found at the autopsy to be entirely aortic. A remarkably elongated saccular dilatation sprang from the arch directly behind the innominate artery (somewhat compressing it) and appeared above the inner edge of the clavicle. The innominate was completely pervious and of normal size. The deception was complete and would have given rise to a grave error of treatment had the patient consented. Although, as in the case just related, mistakes of this kind are sometimes quite unavoidable, yet, in the majority of cases, a thorough investigation of all the symptoms and physical signs will suffice to make a diagnosis.

Aneurisms of the descending thoracic aorta are less common than the others. They also may be cylindrical or saccular. From the depth at which they are situated in the chest, and from the thickness of the structures everywhere surrounding them, they are difficult of detection, and as the symptoms from them may be only slight and ill defined, they may continue for a long time unsuspected. Pain is, however, seldom absent, and, if long continued, points strongly to aneurism. This point has been already sufficiently dwelt upon. The earliest physical signs consist in localized dulness to the left of the spine, and enfeebled breathing over the same area. Later on, a systolic bruit may be heard. Occasionally, retardation of the left femoral pulse, as compared with that of the radial, has been observed. When of large size, the aneurism pushes the heart forward, and the heaving impulse of the tumor can be felt anteriorly through the heart. A rare symptom is dilatation of the veins on the anterior aspect of the chest from pressure upon the azygos and intercostal veins. Lying against the vertebral bodies, these aneurisms very commonly produce erosion of those structures; and if this be sufficiently considerable, bending of the vertebral column occurs, with posterior curvature. From this cause, or from opening of the vertebral canal, pressure is sometimes brought to bear upon the spinal cord itself, with a resulting paraplegia. The œsophagus is sometimes compressed and dysphagia produced. Attacks of pleuritis in the lower part of the left side are a very frequent accompaniment. These usually result in plastic effusion, but, at times, even pretty considerable quantities of serum may be found. Some years ago I found a hospital patient complaining of stitching pain in the left side. Very moderate effusion was determined by physical examination. There had been slight pain in the back for some time previously, but this had not been of sufficient duration or intensity to lay stress upon. The fluid continued to collect, and was removed by aspiration, with relief. A few days afterward he died suddenly from rupture of an aneurism of the descending aorta into the same pleural cavity.

Rupture of these aneurisms occurs most frequently into the left pleural cavity, sometimes into the right, and occasionally into the œsophagus. Cases are known in which the sac opened into the spinal canal.

Diagnosis.—The recognition of thoracic aneurism is just as easy in some cases as it is difficult in others. During the past decade it has become more generally recognized that a not inconsiderable number of cases of aneurism are entirely latent. An important advance in the recognition of such cases has been made by the application of the *x*-rays. Cases otherwise obscure can be cleared up by these remarkable rays, and when aneurism is falsely suspected an *x*-ray examination may disprove its existence. Observations are best carried out by means of the fluorescent screen, when a distinct enlargement lying in the course of the aorta is detected. Pulsation is sometimes observed, and, when present, strengthens the view that an aneurismal tumor is present. Williams states that the movements of the diaphragm are often less on the left side, due probably to pressure on the left bronchus. Care must be exercised not to mistake enlarged glands or other intra-thoracic tumor for aneurism. Such an error is only likely to occur when the growth lies in contact with the aorta.

Superficial, strongly pulsating aneurisms are readily observed, and not unfrequently the throbbing will have been noticed by the patient himself. On the contrary, deep-seated dilatations may give no appreciable physical signs, and in that case the diagnosis may be obscure. Furthermore, if, in one of these obscure cases, the aneurism causes no symptoms by its pressure, then the diagnosis becomes impossible. Not a few aneurisms of the ascending arch, even of considerable size, prove the cause of sudden death in persons previously believed to have been in good health. These, having caused no symptoms, had never been looked for, but could undoubtedly have been detected by physical examination. The combination which gives the greatest certainty to the diagnosis of thoracic aneurism is the union of physical signs of tumor with pulsation in the course of the aortic arch, together with some, or best, several, of the pressure symptoms enumerated. The difficulties in the diagnosis of these cases arise from the great variability which is met with in the manner in which these different indications may be grouped together. Thus we meet with cases in which some of the physical signs of aneurism are observed, and no pressure symptoms; others, again, in which there are evident pressure symptoms,

with perhaps only a few of the signs of aneurism. In not a small number of cases the conditions lead to the recognition of an intra-thoracic tumor, and the difficulty begins only when we endeavor to differentiate between *a solid tumor* and *an aneurism*. The resemblance between an aneurism and a solid tumor placed between the chest walls and the aorta may be very close. In both there may be dulness on percussion, pulsation, and a recognizable bruit, and pressure symptoms of identical character may also be present. The chief points of distinction are the following: In the case of the neoplasm, the dulness is likely to be less clearly restricted to the aortic region, the pulsation will not be at all so forcible, and the systolic bruit will probably not be followed by an accentuated second sound. Bronchial respiration is commonly heard over a solid tumor, while enfeeblement or silence is the rule in aneurism. Again, persons with aneurism are not likely to suffer severely in their general nutrition and appearance, while the contrary holds good with reference to nearly all forms of intrathoracic solid growth. Attention to the following points may also assist the investigator in doubtful cases. Aneurism is many times more frequent than solid tumor. It occurs much more often in men than in women. It is favored by a history of rheumatism, strain, alcoholism, or syphilis. (Fifty per cent. of patients with aneurism have had syphilis.)

Pulsating empyema is a rare condition, which sometimes simulates aneurism. The chief physical signs to be here met with will be dulness on percussion and local pulsation, but no pressure symptoms will be present. Examined closely, the dulness will be observed to be less clearly localized in the aortic region than is that of an aneurism. Moreover, other signs of arterial disease will be wanting, and, on the other hand, there will be some evidences of disease in the pleura or the lung, accompanied by a certain degree of constitutional disturbance. These differences will usually suffice to prevent error. Puncture with a fine aspirator needle will, in any case, clear up the diagnosis.

Violent throbbing pulsation of the aorta in cases of severe aortic regurgitation often leads to a suspicion, or even to an erroneous diagnosis, of aneurism. The pulsation, however, has not the heaving character of aneurism, and there is an absence of pressure symptoms.

PROGNOSIS.—It is usually a matter of considerable difficulty to form a satisfactory opinion as to the prospects of life of a person suffering from thoracic aneurism. Undoubtedly the disease generally tends to prove fatal, and is actually the immediate cause of death in the majority of cases; and yet, in a certain number, increase in the tumor is arrested and moderate health is enjoyed for perhaps a period of several years, even then the fatal event being brought about by some affection entirely independent of the aneurism itself. It is often clearly impossible to estimate at all accurately the size of a deep-seated tumor, or the degree to which it may lie against important adjacent organs; and hence ruptures in various directions, which no skill could possibly foresee. Those aneurisms which arise from the root of the aorta are the most dangerous, as they tend most frequently to rupture while yet small. Those of the ascending arch—if they grow forward and to the right—are calculated to permit of the longest tenure of life. Those of the transverse arch and descending thoracic aorta are probably, on the whole, more favorable than the first and less so than the last; the reason for this, of course, being their greater proximity to numerous important structures, which can hardly escape from injurious pressure. Our opinion, therefore, of the probability of the prolongation of the patient's life must depend upon the situation of the aneurism, the fluidity or the contrary of its contents, and the presence or absence of symptoms of compression, to a serious extent, of the surrounding parts. If this be well marked upon the trachea or œsophagus, a fatal result may be anticipated before many weeks or months. Other conditions to be considered are the following: Mode of life; if a person with aneurism is obliged to earn his living, and especially if the occupation followed is at all laborious, his chances of living will be far less than those of his more favored fellow who is able to live at ease and free from care. Rest is so important in these cases that if this cannot be secured the disease is almost sure to be progressive, and perhaps even to advance rapidly, while, on the other hand, it seems sometimes surprising how long the fatal end can be averted, even in advanced cases, by the observance of great precautions in this respect. This remark will also necessarily apply to the cases of patients who, from irritability of temper or other similar causes, refuse to carry out this essential principle of their treatment. The temperament of the patient is of importance, for anger, excitement, and, indeed, any violent reaction may be followed by the most serious results. Indulgence in alcoholic liquors is sure to interfere with the quiet action of the heart which is so desirable; intemperance must, therefore, influence strongly our prognosis.

Associated Conditions.—In estimating what is likely to be the future of any given case of thoracic aneurism, it is important to study carefully any pathological conditions which may be associated with it—such, for example, as affections (especially valvular) of the heart, of the lungs, of the larynx, of the bronchi, etc.—and to assign to each its true value as a factor in the problem. Finally, the general condition with reference to nutrition, muscular development, digestion, etc., must also take its place in rendering the prognosis either more or less favorable.

TREATMENT.—Aneurism within the chest is capable of the same spontaneous cure which occurs occasionally elsewhere. Complete coagulation and hardening of the contents, with arrest of all symptoms, is, however, extremely rare. Still it is always obviously a duty to endeavor to place a patient who is the subject of this formidable disease in as favorable a position as possible for this process to occur. All treatment, therefore, which is not merely palliative should be directed toward insuring conditions likely to promote firm coagulation within the sac.

In the large majority of cases of intrathoracic aneurism we are, from the nature of things, precluded from those methods of treatment which are applied directly to the tumor itself or its immediate neighborhood, and are frequently distinctly curative. We are, on the contrary, compelled to treat these cases by general measures and by such indirect means—drugs—as experience has proved to be of value. The objects in view may be briefly stated to be to reduce the tension within the aneurism, to secure regularity of the heart's action without frequency, to maintain the blood in good chemical condition without undue bulk, and to favor thickening of the sac's walls. To follow out these indications it is necessary to secure the full direction of the case for, perhaps, several months. If the physician, therefore, is to meet with any success, it is absolutely requisite that he should have the hearty coöperation of the patient, who, if sufficiently intelligent, must be made acquainted with the nature of the case and the urgent need of his assistance, irksome though he may find it to be.

The recumbent position, for a length of time, is always to be recommended. The effects of this measure alone are often sufficiently striking. When the person's circumstances permit, the restriction to a lying posture should be absolute, and should be persisted in for several months, unless the general health appear to be suffering materially from the close confinement, when, with due precautions, sitting up and slow walking may be permitted. If, on the other hand, circumstances prevent absolute rest from being carried out, then, at any rate, very stringent rules must be insisted upon, governing the patient's entire mode of life, with the view of insuring the least possible muscular exertion. This is a point on which too much stress cannot be laid. These patients live constantly on the edge of a precipice, yet, when immediate suffering is relieved, this fact is too often lost sight of, with disastrous results. A patient whom I

treated during a year not long ago, for an aneurism of the ascending arch, was so far benefited that he took a situation as a messenger. In spite of all warnings to the contrary, he soon undertook to handle heavy baskets and other packages. One day, shortly after, he experienced sudden pain in the chest, followed by the extraordinarily rapid development of an external tumor. This quickly attained the size of a child's head, and proved fatal, with great suffering. Hardly less important than physical rest is mental quietude. Habitual worries of all kinds should be as much as possible excluded, while actual excitement is in every respect highly dangerous. A fit of anger or other violent emotion may prove fatal, either by actually causing rupture of the sac or (as in a recent case of my own) from syncope.

The *diet* is a matter of importance. A very old treatment of aortic aneurism is that of Valsalva, in which repeated blood-lettings were practised, together with a gradual restriction of the food until the amount of this was brought within the lowest possible limits short of actual starvation. The fallacy of this proceeding has, however, been long ago demonstrated. Blood-letting has but little, or but a temporary, effect upon the blood pressure; and the withdrawal of food causes anæmia and weakness, with irritability of the heart and impaired nutrition of the arterial walls, which conditions indirectly aggravate the disorder. The result of experience shows that the formation of a coagulum, which is likely to be of service in the process, will proceed better if the patient be not too much reduced. Tufnell, of Dublin, is the only comparatively recent writer who has advocated the starvation plan. Conformably with his recommendation, the system has been extensively tried, but few are found who can report results calculated to lend support to its efficacy. As much nourishing food should be allowed as can be thoroughly digested, due allowance being made for the weakened digestive activity that results from the enforced rest in bed. If the patient be plethoric and show evidences of congestive tendencies, then our treatment may well be begun by the adoption of depletory measures for a time—a low diet with laxatives or saline purgatives.

As regards medicines, many have been tried, but few have proved useful. The most valuable drug is undoubtedly iodide of potassium. The good effects of the iodide were described by Dr. Chuckerbutty in 1862, and by Dr. Roberts in 1863, and they were emphasized and enlarged upon by Dr. George Balfour a few years later. Since that time it has been extensively employed, and has continued to grow in favor. The two former writers considered that it acted by inducing increased coagulability of the blood, but this view is not shared by Dr. Balfour. He considers that the iodide has "a peculiar action on the fibrous tissue, whereby the walls of the sac are thickened and contracted, while if coagulation should take place within the sac, it plays but a very secondary and unimportant part, depending for its occurrence solely on the remora of the blood, and is in no respect due to the iodide of potassium." This corresponds entirely with the results of my own observations, for in one case, in which the relief to pain and the general improvement had been very marked for a long time under this treatment, the autopsy subsequently showed that not a particle of fibrin had been deposited on the walls of the sac. Dr. Bramwell suggests that it acts by reducing the blood pressure and relieving the tension within the sac. The symptoms which specially indicate the use of the drug are pain and troublesome cough. The special pains of thoracic aneurism are generally very rapidly allayed, and are often for a great length of time held in abeyance by this agent; and the same may be stated with reference to the troublesome attacks of irritating cough which the tumor may excite from time to time. Independently, however, of its employment for the relief of these urgent symptoms, it is to be administered steadily for such a time as may be thought necessary to influence, as above, the disease itself. The dose usually given varies from gr. x to gr. xxx. thrice daily. Balfour, who formerly inclined to the larger dose, thinks now that fully as good effects can be obtained from smaller ones. His rule is to employ such a quantity as will lower the blood pressure without increasing the frequency of the cardiac contractions. Beginning with ten-grain doses, ascertain the pulse rate (the patient being recumbent), and increase to fifteen; if no increase in the pulse be observed, this is to be continued; but if the pulse gets quicker, then return to ten. It is rare that more than fifteen grains can be borne within the limits of this test. The treatment must be persevered in, at the least, for several months, and, to give it a fair trial, probably for a whole year, or even longer. If troublesome eruptions are produced by the potash, an intermission must be allowed till these are recovered from. It is also well to remember that some persons who are thoroughly intolerant of iodide of potassium can take iodide of sodium without any outward effects. Dr. Balfour speaks truly when he says the results (from iodide treatment) "are extremely encouraging; and when we reflect upon the entire absence of any risk to the patient from the treatment, and the almost certainty of relief to his sufferings and prolongation of his life being at least attained, I think I am warranted in saying that no treatment for internal aneurism hitherto devised holds out anything like an equal prospect of relief, if not of cure, with that by the iodide of potassium."

Tannic acid and acetate of lead have both been given with a view to promote coagulation within the sac and to favor contraction of its walls. No reasonable degree of success has followed in either case, even although the latter salt has repeatedly been pushed to the production of full toxic effects. I have tried it in one case of aneurism of the abdominal aorta, continuing its use until a deep blue line appeared on the gums, but without any noticeable change in the size of the tumor or the strength of the pulsations.

Ergotin, given internally (or by hypodermic injections), on theoretical grounds, to contract the vessel, has failed to produce any reliable results.

The hypodermic injection of a one-per-cent. solution of gelatin in normal saline solution has been strongly recommended by Lancereaux, with the view of causing coagulation in the sac. From 50 to 100 c.c. may be injected beneath the skin of the buttock, or thrown deeply into the muscles. There is sometimes considerable local pain and even general febrile reaction after this procedure. Although successful cases have been reported, the method is by no means free from danger. Serious and even fatal results have followed the injections, owing to the detachment of large emboli. The method is, therefore, not likely to come into very general use.

Mr. Christopher Heath and a few others have suggested and practised ligature of one or more of the great branches of the aortic arch, the object, of course, being to retard still further the blood current and thus promote coagulation. Some support is given to this procedure from the benefit that has been observed in certain cases of aortic aneurism in which the carotid and subclavian of the right side had been ligatured, under the impression that the disease was confined to the innominate artery. At most it would be applicable only to cases in which the tumor was sacculated and either involved the root or was situated close to the origin of some of the great vessels. Evidence of extensive atheromatous disease would preclude any prospect of advantage from this surgical procedure.

Attempts have also been made to produce rapid coagulation of the blood within the sac by the introduction therein of foreign bodies. Fine iron wire, watch-spring, and horsehair have been employed for this purpose. The results, however, have been more or less disastrous. The coagulum thus formed is soft or friable, and consequently very liable to the detachment of emboli, and moreover it is actually loose in the centre of the sac, instead of being regularly laminated upon its sides. Inflammation of the sac is liable to occur, and as there are no means of keeping this within the bounds of safety,

it may itself cause dangerous symptoms. With the use of strict aseptic precautions this risk is, however, reduced to a minimum. The principle seems faulty, and the absence of good results has caused the treatment to be abandoned.

There still remains to be mentioned a form of treatment which has seemed to be of service in a few cases of otherwise desperate character. That is *galvano-puncture*. The use of electricity in this way is permissible only after a fair trial, for a sufficient length of time, of complete rest and iodide of potassium. It is advised in sacculated aneurisms which are situated near the surface of the chest, have resisted treatment, are rapidly enlarging, and threaten soon to rupture. This method, in suitable cases, has met with a certain measure of success, but it has much more frequently failed of its object, in some instances even having caused dangerous inflammation of the sac, and in others having hastened the occurrence of rupture. For galvano-puncture it is necessary to employ a battery of considerable strength, the Leclanché or Stöher element being what is generally preferred. Experiments have been made with one needle only or with both introduced within the sac. From these it seems to be generally admitted that it is necessary to pass in only one or two needles connected with the positive pole, while the negative is attached to a flat metallic electrode on the surface of the abdomen. It is recommended either to continue the current for a short time only, say twenty or thirty minutes, by which time a small clot will have formed, and this will constitute a nucleus for further deposition; or else to allow the current to pass for a time sufficient to coagulate the entire contents of the aneurism, say for two or three hours. It may be necessary to repeat the operation after an interval of some days.

Another method of producing coagulation within the sac has been suggested by Macewen: A needle is introduced into the sac and the inner wall scratched with its point. The object is to produce an exudation of leucocytes with the formation of firm, white thrombi. The needle should never be left in for more than forty-eight hours and often for a shorter time. It is sometimes necessary to repeat the process several times. In the case of large aneurisms several needles may be introduced so as to irritate a large portion of the lining of the sac. This method has been employed in too small a number of instances to warrant us in drawing any trustworthy conclusions as to its value.

The method of all others which seems to hold out the greatest prospect of success, when it is decided to penetrate the sac, is that first suggested by Corradi. It consists in the introduction of coils of gold or silver wire into the sac through a hollow needle, combined with the passage of a strong galvanic current, the anode being connected with the wire. There can be no doubt that a firm coagulum forms about the wire, and in favorable cases pulsation of the tumor lessens or ceases. Four successful cases have been recorded in America, and with the improved technique suggested by Stewart, a greater degree of success may be looked for in the future. A full account of the technique will be found in Stewart's papers in the *American Journal of Medical Science*, 1892 and 1896.

Although the special treatment of thoracic aneurism in the majority of cases consists of prolonged rest and the administration of iodide of potassium, as above detailed, there are besides these certain therapeutic measures at our command for the relief of individual symptoms.

Excited cardiac action and palpitation are best relieved by the judicious use of tincture of digitalis and the employment of a bladder of ice over the front of the chest.

The pain, it has been already stated, is generally best treated by the iodide of potassium. If, however, it be very severe, it may be necessary to use hypodermic injections of morphine until the iodide shall have had time to act. Moreover, we do meet with rare cases in which the effect of the iodide ultimately becomes lost, and our only resort is the frequent use of morphine to make life bearable. One very marked case of this kind came under my notice in the person of a hospital patient. His aneurism was as large as a cricket ball, and almost as solid. Neuralgic pains were complained of persistently, were relieved for a considerable time by the iodide treatment, but, for more than a year previous to his death, we were obliged to administer daily hypodermics of morphine in considerable quantity. Pain of well-defined neuralgic character (especially along the intercostal nerve) is decidedly benefited by the application of small blisters over the most tender parts.

Dyspnœa, if due to accompanying catarrh, must be treated with reference to the latter disorder. But if, as is most frequently the case, it is the result of mechanical pressure and irritation of nerves, recourse must be had to sedatives and narcotics, especially morphine and hydrocyanic acid. Alcohol in tolerably full doses is also of considerable assistance.

If a projecting tumor form, care must be taken to protect it from injury or friction by some arrangement of pads or a shield of some smooth metallic substance lined with cloth.

When rupture has actually taken place, we can probably do nothing; but, if any preliminary bleeding should occur, we may endeavor to prevent this going on to rapid hemorrhage by the use of ice externally and the administration of astringents with ergot, while the most perfect quietude is enjoined. *George Ross.*

Recent Literature.

Hershey: *Therapeutic Gazette*, September 15, 1896. (Introduction of gold wire into an aneurism of the innominate artery; application of galvanic current for a period of one hour and twenty minutes; partial solidification of contents of aneurism; patient remained well for nine and a half months after the operation.)

Stewart: *British Medical Journal*, August 14, 1897. (Report of post-mortem conditions found in a very large innominate aneurism after the introduction of a coil of gold wire.)

Langton: "Treatment," May 25, 1899. (Report of a case of aneurism of the abdominal aorta cured by the introduction of silver wire into the sac.)

Lancereaux et Paulesco: *Gazette des hôpitaux*, No. 71, 1897. (Injections, at intervals of from two to five days, of a solution of gelatin into the subcutaneous tissues, in a case of aortic aneurism; diminution in size and increased firmness of the aneurismal tumor; disappearance of the pain.)

Lancereaux: *Journal des praticiens*, November 19, 1898. (Further details in regard to the technique which he employs in the treatment of aneurism by the subcutaneous injection of solutions of gelatin.)

Stoicesco: *Journal de médecine interne*, July 21, 1899. (Reports of six cases of aneurism of the aorta and innominate artery treated by the gelatin method.)

ANGELICA.—*Angelica* L. (fam. *Umbelliferæ*) is a genus the limits and dimensions of which are greatly in dispute among botanists, the various sub-genera of one author being regarded as so many distinct genera by another. As recognized by Messrs. Engler and Prantl, whom we follow, it contains about twenty-five species, most of them natives of the cool temperate regions of the northern hemisphere. The plants abound in the aromatic principles of the family. A number of them have been employed in domestic practice, and two, under the names "European" and "American" angelica, have been very extensively used in medicine

European Angelica is the rhizome and roots of *Angelica archangelica* L., a biennial, four to six feet high, with a stout, hollow, purple-green, fluted stem, large decompound leaves with clasping petioles, and large umbels of white flowers. It is a native of far Northern Europe and Asia, and is very extensively cultivated, our commercial supplies coming mostly from cultivated plants of Germany and France.

It is one of the few vegetables whose use began in the extreme north of Europe and extended southward. It

was an article of food in Norway and Iceland many years ago, when its spicy taste made it a grateful addition to the monotonous diet of the North. Later, in the fifteenth and sixteenth centuries, it was generally cultivated throughout Central Europe. Since then, the use of angelica has been gradually diminishing, milder-flavored vegetables taking its place, and it is only grown at present to fill a very moderate demand in domestic and veterinary medicine, confectionery, and liqueurs.

It is important to note the extensive use of the "candied" stems (*Angelica glacé*) as a confection, since important cases of poisoning sometimes result from the ignorant use of certain toxic plants which bear a close resemblance to this.

The root consists of a large short rhizome, terminated above by a hollow stem, and often worm-eaten. Below, it divides into numerous thick, fleshy roots, 4 mm. (one-eighth of an inch) in thickness, and 25 or 30 cm. in length, of a blackish-brown color, much wrinkled longitudinally, and tuberculated. They are rather soft and pliable, brownish white within, and in the dried specimens lie in a parallel tress or bunch. The odor is rather pleasant; the taste at first sweetish, later bitter and musky. Radially arranged oil, etc., ducts are to be seen under the microscope on section, chiefly in the cortical portion.

The constituents of angelica are, first, an *essential oil*, of which it yields from eight-tenths to one per cent.; this has the odor of the plant and the usual carminative qualities of the oils of the order. Second, six to ten per cent. of resin. Third, *angelic acid*, one-third of one per cent., discovered by Buchner in 1843, and since found in a number of other plants, as well as made by synthesis; an odorous crystalline volatile acid. Fourth, a very small amount of valerianic acid, together with the crystalline angelicin, an amaroid, and a little each of starch, tannin, and sugar.

Its properties are aromatic, stimulant, carminative, and flavoring, as usual in the family. The dose is from 0.6 to 2 gm. (gr. viij.–xxx.).

Angelica oil from this source is an article of commerce.

American Angelica is the root of *Angelica atropurpurea* L., a plant of very similar habit to the last, growing in Northeastern North America. The roots grow in the same manner from a similar rhizome, but are marketed detached therefrom. They are somewhat larger than those of the European, and are of a light gray brown color. The composition and properties are practically the same, though the root and the oil have a perceptibly different odor and taste. *H. H. Rusby.*

ANGINA PECTORIS. See *Heart, Neuroses of the*.

ANGIOKERATOMA.—(Synonyms: Kerato-angioma; Telangiectatic Wart.)

DEFINITION.—An unusual skin disease, chiefly met with on the hands and feet of those subject to chilblains. It consists of single and grouped papular and nodular lesions of a reddish or purplish color, made up of epidermic hypertrophy covering dilatation of the capillary vessels in the papillæ.

HISTORY.—Mibelli gave the first anatomical description of the condition met with in the affection and proposed the name "angiokeratoma" for the disease. The lesions which formed the basis of his observations occurred on the dorsal surface of the fingers of a fourteen-year-old girl, and had existed for several years. They were preceded by chilblains.

Before Mibelli's careful investigations, cases of the same affection had been noted by other writers under various names; the true nature of the lesions had not, however, been determined.

We are indebted to Pringle for a most accurate and painstaking description of the clinical appearance and morbid anatomy of the affection, as well as for an analysis of most of the cases which had been met with up to the time of his publication.

Pringle reported two cases affecting girls with chilblains, and his histological findings agree in all essential points with those of Mibelli. Since the publication of these cases a number of others have been reported, among them Zeisler's, which presented, in addition to characteristic lesions on the hands and feet, nævus-like patches and pedunculated vascular tumors on the forearms, over the patellæ, the legs, thighs, and auricles.

In the case reported by myself, the skin of the scrotum was the seat of a number of small, spherical-shaped, dark purple tumors. They were arranged in a linear manner as if following the superficial vascular supply of the parts. The small growths, from the size of a pin's head to several times that size, were distinctly elevated above the surface of the scrotum, seeming to rest on it rather than to be embedded in the skin. Some of them were covered by a slightly thickened horny layer under which minute dark red points could be seen, giving the tumors a wart-like appearance. In this patient the hands and feet were not involved, and the usual etiological factor, chilblains, could not, of course, be invoked to explain the development of the lesions.

FIG. 201. Section through Small Blood Cavity Completely Enclosed by Hypertrophied Rete. Thickened epithelium at right of section. Spencer, one inch; ocular, one and one-quarter inches.

FIG. 202.—Large Tumor Showing Cavernous Spaces Divided by Fibrous Septa. Organized blood clots on the left of section. Spencer, one inch; ocular, one and one-quarter inches.

palms and soles may be involved. On parts of the body where the stratum corneum is thinner than on the hands and feet its hypertrophy is less marked than in the latter localities and may not be perceptibly thickened. It is usually bilateral, though not strictly symmetrical. The affection may persist indefinitely, become stationary, or disappear.

PATHOLOGY AND MORBID ANATOMY.—The primary change is undoubtedly in the capillary vessels of the papillæ, which, subjected to repeated congestions, become permanently dilated, leading to the formation of cavernous spaces, and by pressure alter the normal conformation of the parts. On the hands and feet the stratum corneum covering the lesions is greatly thickened; this change is not so pronounced, however, when the affection is met with in other regions. The characteristic pathological changes are shown in the accompanying photomicrographs made from sections of tumors removed from the scrotum.

In Fig. 201, a small cavity filled with red and white blood corpuscles is shown completely surrounded by the hypertrophied rete layer.

On the right of Fig. 202, a large cavernous space is seen to be filled with blood corpuscles, which have by pressure caused a marked atrophy of the epidermis.

I have lately, through the kindness of Dr. Leviseur, seen a similar case in which the small tumors were seated on the vulva of a young girl. The diagnosis, in this case, was confirmed by the microscope.

Anderson has reported a case in which the eruption began over the knees at the age of eleven years, gradually spreading to the trunk and upper extremities, and finally involving almost the entire surface of the body with the exception of the hands and feet.

SYMPTOMATOLOGY.—A history of recurring attacks of chilblains precedes the development of the affection on the hands and feet. After a variable time minute telangiectases appear over the dorsal surfaces of the phalanges of the fingers and toes, which eventually cannot be made to disappear by pressure. The points of vascular dilatation become grouped, and over them the epidermis undergoes thickening, giving rise to hemispherical lesions from the size of a pin's head to that of a split pea, or larger, having a rough warty surface and a dark purple or lead color.

The minute vascular points beneath the thickened epithelium can be detected by making pressure on the growths.

In some cases lesions in all stages of development from minute pink points to the commingled warty growths can be detected. The

FIG. 203.—Cavernous Spaces Filled with Blood Corpuscles and Divided by Fibrous Septa. Hypertrophy of stratum corneum and rete Malpighii. Spencer, one-half inch; projection ocular, 2 Zeiss.

On the left of this section the circulation has been obliterated, as the lacunæ are occupied by concentric layers of fibrin containing blood corpuscles and pigment.

Fig. 203 represents a more enlarged view of the cavernous spaces with their divided septa. The stratum corneum is also shown to be considerably thickened.

An examination of the sections shows that the lesions consist of lacunar spaces filled with blood occupying the papillary portion of the derma, some of which are enclosed in the rete Malpighii. These cavernous spaces are evidently the essential feature of the disease and the primary pathological condition.

ETIOLOGY.—The disease, when it occurs on the hands and feet, as it most frequently does, is an affection of early life, and caused by repeated attacks of chilblains.

Some cases have been associated with tuberculous affections of the lungs, glands, and other regions. An attempt has been made by Leredde to show that it is caused by the toxins of the tubercle bacilli.

In my case, in which the skin of the scrotum was affected, the tendency to dilatation of the blood-vessels as manifested by a double varicocele, and the degenerative state of the vessels and surrounding connective tissue incident to old age, were probably the most potent causes in bringing about the condition.

DIAGNOSIS.—A well-developed case of the disease could hardly be mistaken for any other affection. The color of the lesion and the presence of the vascular points should differentiate it from tuberculous or ordinary warts.

TREATMENT.—The tumors may be removed by excision or by the application of the Paquelin or galvano-cautery, with the production of slight scarring. Less deformity results from electrolysis. *John A. Fordyce.*

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ANGIOMA.—(ἀγγεῖον, a vessel.) The angioma, a neoplasm representative of the connective-tissue or histoid type of tumors, is a new growth composed wholly or in great part of blood-vessels or of lymph vessels. The term angioma is sometimes, though inaccurately, employed to designate one of the varieties of the species of tumor bearing this name, the hæmangioma, a growth consisting of blood-vessels.

Classification: According to the character of the vessels entering into the structure of the tumor, angiomata are classified into—1. Hæmangiomata; 2. Lymphangiomata.

1. HÆMANGIOMA.—The hæmangioma is a tumor the essential structural components of which are newly

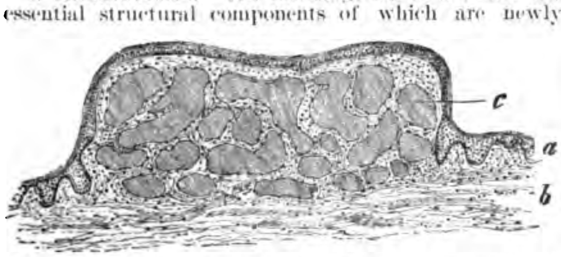

FIG. 204.—Angioma Cavernosum Cutaneum Congenitum. (Müller's fluid; hæmatoxylin.) *a*, Epidermis; *b*, corium; *c*, cavernous blood spaces. × 20 diameters. (After Ziegler.)

formed blood-vessels. It is to be distinguished from other blood-containing tumors, such as hæmatoma and certain forms of aneurism, notably aneurisma racemosum and varix racemosum. These latter are the result of dilatation and hypertrophy of pre-existing vessels, and bear no relation to structures whose component elements are essentially the product of new growth. The hæmangiomata have been designated *erectile tumors* by reason of their analogy to the corpus cavernosum penis and to other erectile structures. The size and consistence of one of these tumors may vary greatly from time to time, such variation depending upon the amount of blood contained within it; this may be increased by exercise, during a fit of weeping, and, in women, during the menstrual period. When from any cause the amount of blood in the tumor is diminished, the latter may become soft and flaccid, to regain its firmness and elasticity when the former condition is restored.

Varieties: Two varieties of hæmangioma are recognized, the distinction between them being based upon differences both in structure and in location. These varieties are:

(*a*) *Hæmangioma Simplex* (nævus vasculosus; birth mark; telangiectatic hæmangioma). This form of hæmangioma comprises the small vascular nævi, and most of the so-called mother's or birth marks. It occurs in two forms: (1) As flat, round, or irregularly outlined, usually sharply contoured, red or bluish-red patches on a level with, or but very slightly elevated above, the surface of the skin; in size, varying from that of a flea-bite to that of the side of the face. The skin over these patches is either smooth or thickened, and is sometimes covered with lanugo hairs. (2) As round, more or less lobulated tumors, in size varying from that of a hemp-seed to that of an apple, situated primarily beneath the skin, the larger growths projecting above it. The skin over them is rarely normal, usually thin, transparent, dark red or purple, and traversed by vessels. They are sometimes covered with hair.

Occurrence. This variety of hæmangioma is very common; it is nearly always congenital. From observations made by Depaul, it appears that one-third of all the children born in the clinic of the Faculty of Medicine in Paris have such hæmangiomata at birth. The tumor is situated most frequently in the skin of the face, neck, back, chest, abdomen, sometimes of the extremities. More rarely it occurs in mucous membranes, and beneath the serous surfaces of the internal organs. It may be single or multiple, and may attain a varying size. The congenital forms remain stationary.

Structure. Histologically, the hæmangioma simplex consists of newly formed, much convoluted, more or less dilated capillaries lying in a stroma composed of fibrous connective tissue or of fat tissue. This stroma varies in amount, and may be infiltrated with lymphoid cells, or contain pigmented connective-tissue cells. The newly formed vessels often correspond in distribution to the vascular districts of the sweat glands or the hair follicles. When the connective-tissue stroma of the flat form of the tumor becomes abundant, or is largely replaced by fat, the growth may assume more of the lobular type of structure.

(*b*) *Hæmangioma Cavernosum* (cavernous tumor; erectile tumor).—This form of hæmangioma consists of lobulated, sometimes fungoid tumors of varying size, bluish in color, single or multiple, tending to diminish or disappear under pressure. Pressure upon parts adjacent to the tumor causes it to swell by venous congestion; other conditions, such as change of position, weeping, sleep, digestion, the ingestion of alcohol, and the like, may cause alteration in size, owing to the erectile character of the growth.

Occurrence. The cavernous hæmangioma occurs most frequently in the *liver*, where it appears as a dark mass situated usually just beneath the capsule, and never elevated above the surface. The size varies from that of a pea to that of a whole lobe of the liver. The tumor is generally single, sometimes multiple. The livers of old people present this form of new growth in a great number of instances. Its occurrence in this organ seems to vary in frequency in different countries: according to the report of pathologists, it is not so frequent in Norway and Sweden as it is in Germany. By the rupture of the vessels of large cavernous hæmangiomata through the

capsule of the liver, extensive hemorrhage has taken place into the peritoneal cavity, and fatal peritonitis has been caused.

This tumor also occurs, although less commonly than in the liver, in the other abdominal organs, as, for example, the *spleen* and the *kidneys*, and also in the *brain*. It

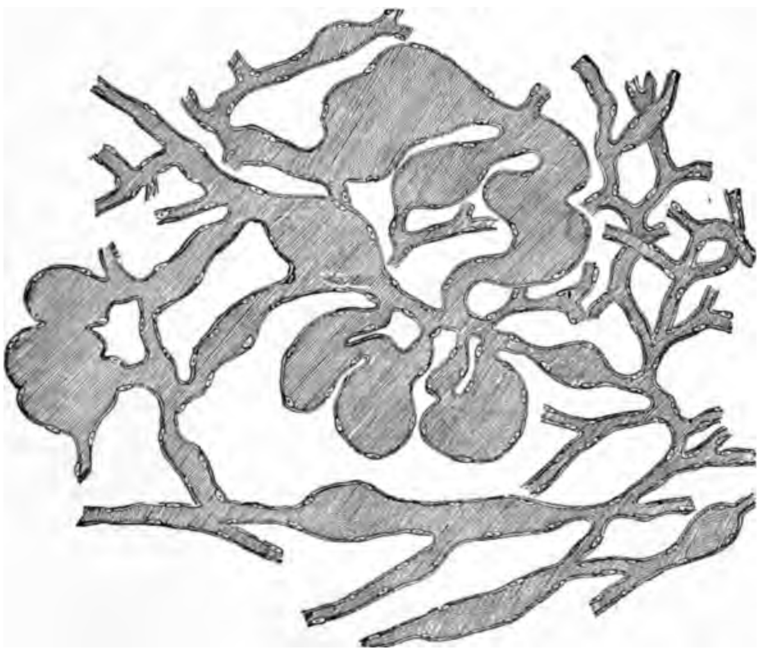

FIG. 205.—Dilated Capillaries from a Telangiectatic Tumor of the Brain, All the Attached Portions of Tumor Tissue having been Shaken Off in Water. × 200. (After Ziegler.)

is found in the *skin* less frequently than are the simple hæmangiomata. Esmarch has reported in Virchow's *Archiv* a very interesting case of its occurrence in this position. A single tumor developed upon the middle finger of a girl eight years of age, followed in subsequent years by the appearance of a great many others. At the time of the first menstruation there was a great increase in both the number and the size of the tumors. At each succeeding catamenial period they seemed to grow more than at any other time. In size they varied from that of a pea to that of a hen's egg. They were all successfully extirpated, and in most cases were found to be situated on the wall of a vein, with which they were in communication.

Cavernous hæmangioma is seldom congenital; it occurs mostly in the earlier years of life, and rarely develops at a later age. It grows very slowly, often remaining stationary.

Structure. The cavernous hæmangioma upon section presents an appearance quite similar to that of the cut surface of the corpus cavernosum penis. It is characterized by the presence of a firm, tough, white, meshwork, which in the recent state is empty or contains some irregular blood clots. The meshes frequently enclose small, round, calcareous masses known as phleboliths. In some instances this cavernous structure is sharply circumscribed and separated from the surrounding structures by a firm capsule. In others, where the tumor is small and to all appearances in a state of rapid growth, it is surrounded by a zone of lymphoid cells. The consistence of the tumor depends upon the amount of the fibrous connective-tissue meshwork, or stroma: when this is abundant, the tumor is relatively hard, and when scanty, soft and flaccid.

Microscopically, the tumor presents trabeculæ of fibrous connective tissue, in part newly formed, in part belonging to the structure in which the tumor is developed, of varying thickness, arranged in the form of a meshwork. The cells of this tissue are numerous, and it is usually infiltrated with lymphoid cells scattered singly or localized in groups. The spaces of this meshwork are lined with flat endothelial cells, and contain blood. These spaces are of varying size, but whatever their extent, they always represent capillaries, for they are interposed between an artery and a vein. Adjacent large spaces may be separated by but very thin partitions. The connective-tissue stroma in some cases has been found to contain nerves, smooth muscle fibres, and elastic fibres.

Etiology.—The cause of hæmangiomata, in common with that of most new growths, is not understood. A large proportion of all tumors of this sort are congenital, and when they do develop after birth, it is generally in the early years of life. It is seldom that hæmangiomata develop in adults, a fact which is remarkable in view of the frequency of dilatation of the blood-vessels in old age, and one which constitutes a strong objection to the theory that these tumors arise from a simple dilatation of pre-existing vessels. Heredity seems to play some part in their occurrence; numerous cases are recorded in which a child presented one of these tumors in the same place on its body as that in which one of the parents also had a birth mark. Popular belief in all ages has associated the presence of these growths in children with some influence exerted upon the mother during pregnancy; maternal impressions cannot, however, be regarded as definite factors in the development and growth of offspring.

Different views have been held regarding the genesis of the cavernous form of hæmangioma, and at one time the subject formed a ground of contention between two of the greatest pathologists, Virchow and Rokitansky. Virchow held that the development of a cavernous tumor was always preceded by the formation of granulation tissue, the newly formed vessels of which afterward became dilated, and the intervening structures atrophied. Rokitansky, on the other hand, did not regard the blood-filled spaces of the tumor as true vessels, but supposed that they were formed independently in the connective tissue, and

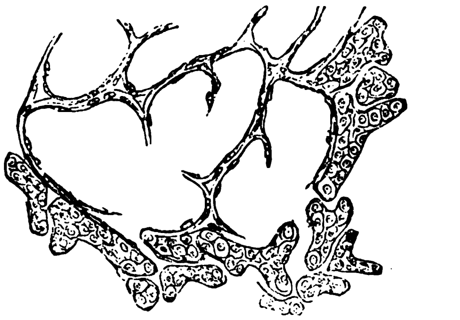

FIG. 206.—Section through the Margin of a Very Small Cavernous Angioma of the Liver at a Time When This Margin Was in Process of Active Growth. (Carmine preparation.) × 150 diameters. (After Ziegler.)

afterward came into communication with blood-vessels. The blood corpuscles he regarded as formed by an endogenous process within certain altered connective-tissue cells. These he called "Hohlkolben," and described them as large protoplasmic masses situated usually along the blood-vessels. These views of Rokitansky seemed to find confirmation in a description by Luschka of such

structures occurring in the small blood-vessels of the brain. It is now known, however, that these so-called blood cysts of Luschka are merely dilatations of the perivascular sheaths of the cerebral vessels. Other investigators at various times in the past have supported the theory of Rokitansky that blood corpuscles are formed in inflammatory tissues, but in the light of more recent knowledge it appears that this never takes place. Rindfleisch held that the hæmangiomata could be developed in any structure provided with blood-vessels, by what he termed "cavernous metamorphosis," a process characterized by the dilatation of pre-existing vessels, resulting either from fibroid degeneration of the capillaries or from the contraction of cicatricial tissue around the vessels. This theory, at least so much of it as depends upon the correlation of the development of cavernous tumors with the contraction of scar tissue, can hardly be regarded as tenable; for in the lung, where we most often find such tissue, hæmangioma almost never occurs, and in the liver, where the tumor is so frequent, its presence cannot be shown to bear any relation to cirrhosis.

It is probable, therefore, that none of the theories advanced to account for the origin of hæmangioma is acceptable other than that which asserts that the tumor is the result of an independent new growth of blood-vessels, the *cause* of growth not being as yet altogether explainable.

Mode of Growth; Clinical Aspects.—The hæmangiomata extend always by growth from within outward; they show no tendency to infiltrate surrounding structures; they do not cause metastases. Instances of seeming exception to these conditions are probably cases in which sarcoma with dilated blood vessels was mistaken for hæmangioma. The pulsating tumors of the long bones, which have been described as cavernous tumors, are to be regarded as telangiectatic sarcomata. The hæmangioma is, therefore, so far as its mode of growth is concerned, a *benign* tumor, although the accidents incidental to its development may cause death from hemorrhage or from intracranial pressure. The growth of these tumors is generally unaccompanied by pain; it is slow, and may be irregular. In some instances the tumor constantly enlarges, in others it reaches a certain size and then remains stationary. It sometimes undergoes spontaneous cure by the ulceration of the overlying skin, and the subsequent formation of cicatricial tissue which includes the vessels and obliterates them by contraction. When, as is sometimes the case, the tumor is connected with the skin by a pedicle, the vessels in the pedicle may shrink, and the tumor become desiccated and drop off. In yet other cases a cure may be effected by thrombosis, and the consequent deprivation of the tumor of its circulation.

2. LYMPHANGIOMA.—The lymphanigoma is a tumor composed of lymph vessels in a state of greater or less degree of dilatation, lying within a fibrous connective-tissue stroma. Strictly speaking, the term lymphangioma is applicable to those lymph vessel tumors only in which the whole or the greater part of the vessels is newly formed; but inasmuch as in any single case it is often difficult to determine how far the vessels are newly formed and how far pre-existing ones, dilated and thickened, it is convenient to include under the lymphangiomata certain abnormal structures in which the essential pathological condition is lymphangiectasis. This form of new growth occurs in a great variety of *loci*, and presents an external configuration determined very largely by the organ or structure in which it is developed, as well as by its histological characteristics. It is seen in warty tumors and diffuse thickenings of the skin and mucous membranes, in macroglossia, in certain congenital cysts, and in various other conditions. The classification of lymphangiomata, based upon structure, according to Wegner, admits of the recognition of the following—

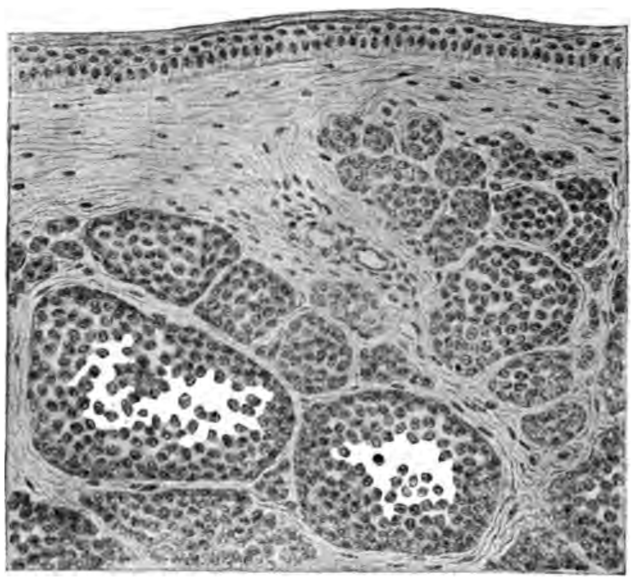

FIG. 207. Lymphangioma Hypertrophicum. Rounded summit of a rather large, soft, smooth wart. (Formalin; hæmatoxylin; eosin.) Sharply limited nests of cells in the corium. × 250 diameters. (After Ziegler.)

Varieties: (*a*) *Lymphangioma Simplex.*—As a true neoplasm this occurs in the form of a circumscribed tumor, composed of capillary and larger-sized lymph vessels. As lymphangiectasis, it is seen in the lymphatic varix, in dilatation of the lymphatics resulting from obstruction, in macroglossia and elephantiasis following erysipelas, and in elephantiasis due to filaria.

(*b*) *Lymphangioma Cavernosum.*—This variety is analogous to the cavernous hæmangioma. Histologically, it consists of larger and smaller spaces, lined with endothelium, and surrounded by a strong wall of fibrous connective tissue. Section of the tumor in the recent state reveals the presence of lymph. The stroma may contain fat, leucocytes, epithelioid cells, blood-vessels, and smooth muscle fibres; the presence of these last is regarded by Stiles as a means of distinguishing lymphangioma from lymphangiectasis. The contents of the spaces are clear and resemble lymph.

Occurrence. The cavernous lymphangioma occurs in the tongue, the lips, the skin, and rarely in the internal organs.

Macroglossia, lymphangioma of the tongue, when not due to obstruction to the lymphatics resulting from inflammatory processes, *e.g.*, erysipelas (Robin, Laredde), is congenital. The tongue is enlarged, and in extreme cases, especially those in which there is inflammation, may extend to the sternum. Its surface is covered with minute cysts. Histological examination shows that the enlargement is due to a new growth and dilatation of lymphatic vessels, and a hyperplasia of the surrounding connective tissue elements. There is present usually a combination of the simple and the cavernous forms of lymphangioma. The enlargement may remain latent or stationary, and then suddenly increase.

Macrocheilia is a similar condition in the lips; it may be associated with macroglossia. It occurs more often in the upper lip than in the lower, but may involve both. Samter examined seven cases of lymphangioma of the mouth and oral cavity; one presented macroglossia, and the rest larger and smaller warty tumors containing watery contents, and situated in the mucosa and submucosa of various parts of the buccal mucous membrane.

In the skin, cavernous lymphanigoma occurs in the

form of relatively circumscribed growths in the corium, characterized histologically by the presence of large round and oval spaces lined with flat endothelium. These lymphatic structures may press up into the epidermis. In the interstitial connective tissue there are many pigmented cells. Lymphangioma occurs also in the subcutaneous tissue, causing diffuse, rough thickening of the skin, and sometimes leading to an elephantiasis of the affected part. Such a condition may involve an entire extremity. On section, clear or slightly cloudy lymph escapes. Microscopically, the structure consists of large spaces lined with endothelium, and an interstitial stroma consisting of fibrous connective tissue or fat, and containing areas of lymphoid cells.

In the spleen, this variety of lymphangioma has been found in a few instances. Barbacci found upon the anterior edge of the spleen a row of small tumors, in size varying from that of a pin's head to that of a hazelnut. They consisted of a collection of cavities of various sizes, more or less completely combined with one another, and containing a yellow, transparent fluid. Microscopically, they presented the characteristics of cavernous lymphangioma.

(*c*) *Lymphangioma Cysticum.*—This form of lymphangioma differs from the cavernous only in that the spaces within it are larger and more cyst-like than are those of the latter. It consists in single or multiple cysts, which occur in various parts of the body, chiefly in the neck and near the sacrum, but also in the extremities, in the tongue, and on the face. More rarely it is found in the peritoneum, and as single small cysts in or between the abdominal organs. When located in the submaxillary region, the tumor not infrequently rapidly extends, becoming more and more pendant until it reaches the sternum. The cystic lymphangioma is known also under the names: hygroma cysticum congenitum, hydrocele of the neck, congenital serous cyst of the neck. By some authorities it is regarded as forming a distinct group of lymphangiomata.

The cystic lymphangioma of the neck is congenital; it is probably not derived from hæmangioma by the obliteration of connections with blood-vessels and the development of secondary communications with the lymphatic system. The fact that the cystic spaces are lined with endothelium and not with epithelium is evidence that these tumors are not derived from either the salivary glands or the branchial clefts. The tumor is situated upon the anterior or lateral surfaces of the neck; rarely upon the back; it may be unilateral or bilateral. Its size varies; it tends to burrow and to extend under the cervical fascia between the muscles of the neck. In this way it may travel down the sheath of the subclavian vessels to the axilla, or it may go into the mediastinum.

Histologically, this form of lymphangioma presents large cystic spaces lined with endothelium, separate or communicating, containing a clear fluid, lying within a stroma composed of fibrous connective tissue, fat, smooth muscle fibres, blood-vessels, and nerves. In some instances the number of blood-vessels is disproportionately great, so that the tumor may present a combination of hæmangioma with lymphangioma.

The cystic lymphangioma may remain stationary, grow rapidly, or undergo spontaneous involution. It is prone to recurrent attacks of inflammation, especially after aspiration. When superficial it may give rise to lymphorrhagia. The more dangerous positions of the tumor are the neck and the sacro-perineal regions.

Mesenteric cysts are usually the result of some obstruction, inflammatory or otherwise, in the mesenteric lymph vessels. In rare instances they may be attributable to the new growth and subsequent dilatation of lymph vessels.

The fluid contents of these cystic tumors are ordinarily clear, alkaline, and albuminous; when inflammation is present blood, cholesterin, and pus may occur. The character of the fluid may vary widely in different parts of the same tumor.

Etiology. — The lymphangioma is essentially a new growth. In exceptional cases only may any other condition, *e.g.*, inflammation, be associated with the cause of tumors of this sort. Lesser, in agreement with many authorities, affirms that simple lymph stasis can never give rise to a lymphangioma, citing in support of his opinion the fact that tying of the thoracic duct and other large lymph vessels has never been followed by this sort of tumor formation, and further that lymphangiomata often occur in regions where there are but very few lymph vessels. The *cause* of the new growth Krynsk believes to consist in local changes in the lymph-vessel walls, changes which he regards as of embryonal origin, as attested to by the congenital character of the growth and its development in childhood. The mode of new growth he describes as chiefly of the heteroplastic sort, *i.e.*, a process in which fibrous and fat connective tissue furnish the cells from which the endothelium of the newly developed spaces originates. Wegner describes another mode of origin, according to which the formation of new lymph vessels takes place in a previously formed granulation tissue. This theory, while difficult to prove, is quite generally accepted. *George Burgess Magrath.*

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ANGIOMA SERPIGINOSUM.—This rare cutaneous disorder was first described by Mr. Jonathan Hutchinson, in his "Archives of Surgery," in 1891, under the title of infective angioma or nævus lupus. Crocker's name, angioma serpiginosum, would seem to be on all accounts the more appropriate. But a handful of cases, six or seven in all, have been reported, and it may be doubted if one or two of these are really entitled to a place in this group. Hutchinson has also published a short account of three other cases, those of Lassar, Tay, and Jamieson. Besides White's case one other, incompletely reported, has been described in America, and Leslie Roberts refers to a case that may belong in this category, although differing from the type in many respects.

In all the cases thus far reported the affection began in early life, in four of them before the age of two years. Small bright red papules, firmly seated in the skin, are the first manifestations. These papules do not disappear on pressure, and have been likened to Cayenne pepper grains. They increase in size slowly, and may reach the size of a pea, when central involution occurs, while the edges continue to spread so that circinate figures are produced. Outside these circles, small new lesions, called satellites by Hutchinson, are continually making their appearance, which also enlarge and undergo central involution so that new rings are formed, which may unite with the original ones. There is no apparent atrophy in the central part that has undergone involution, but in White's case there was a dull pigmentation in this portion. In none of the cases thus far reported has there been any breaking down or ulceration of the papules.

In Hutchinson's cases the lesions were situated on the back of the arm, spreading upward to the shoulder and downward below the elbow. In the other cases, the arm and side of the thorax, the face and upper extremity, and the lower extremity, have been the portions affected.

White's case, which was seen and studied by the writer, concerned a boy of twelve years, who had always been delicate and of a very nervous temperament. At birth a semilunar red mark was noticed below the right shoulder

blade, which increased very slowly in an upward direction until he was four years old, when another spot the size of a pin's head made its appearance near the first one, which gradually grew larger, and since then other spots have continually appeared and grown larger. When the patient was first seen, the affection formed a band three inches wide, which extended from the anterior edge of the right scapula about six inches forward toward the nipple, and was composed of about twenty-four different lesions, which varied in size from a pin's head to circular patches more than two inches in diameter. Minute elevated points, of a bright red color, first made their appearance, which increased slowly in size until they were from one-eighth to one-twelfth of an inch in diameter. They were of firm consistence, and only partially disappeared under long pressure. Involution in the centre then began, while the growth spread peripherally, so that circles were produced, until by confluence with other lesions near by this shape was lost. The skin in the centre of the lesions appeared normal except for the presence of a distinct pigmentation. New lesions were continually appearing at a little distance from the older areas, and in one or two instances small foci were apparent in the old central portions. The anterior group of lesions, some seven or eight in number, were at one time destroyed by the Paquelin cautery. Pale cicatricial tissue was formed at the side of the cauterization, and it looked as if the operation was successful, but after a time the lesions appeared on the borders of these scars, and the original condition was produced. In this case there was the greatest sensitiveness to slight pressure upon the affected region, but it is not improbable that this was due to the extreme nervousness and fear of the patient. There was also some itching complained of.

The only careful histological examination that has been made of this remarkable disorder was that of White's case. A typical lesion was excised and one-half was studied by Darier of the St. Louis Hospital, Paris, and the other half by Councilman and the writer. Microscopically, the epidermis and the epithelial appendages of the skin, such as the hair follicles and sweat glands, were unaltered. The lesion was characterized by groups of cells throughout the corium, which were fairly well circumscribed, and ran in their general arrangement parallel to the surface of the skin. They were sometimes round, but more often elongated in shape, and sometimes extended out in long ribbon-like masses, which seemed to be formed by a coalescence of neighboring groups. The papillary layer of the corium was only here and there invaded by the process. Under a high power the nuclei were seen to be oval in form with a general direction parallel to the course of the mass. They were surrounded by a small amount of protoplasm, and the boundaries of the individual cells could not always be distinctly made out. The cells of all the groups were arranged in smaller groups or clumps, concentric in form, and in the centre a lumen could sometimes be seen, showing their connection with the vessels of the skin. There were also various changes in the vessels, consisting in a swelling and proliferation of both endothelial and perithelial cells. A striking feature was the presence of small granular masses here and there in the cell groups, which showed no definite structure, and which were evidently produced by a degeneration of the cells, as there was every gradation from slightly granular, poorly staining cells to a total necrosis. In some places the cell groups were situated about spaces and fissures which evidently corresponded to lymphatics. Taken as a whole, the process is evidently one connected with the vessels of the skin, affecting certain groups of vessels, notably the blood-vessels. It seems to begin by a proliferation of the endothelium of the vessels accompanied also by a proliferation of the perithelium, which is followed later by a degeneration and necrosis of the central cells. There is apparently no complete new formation of blood-vessels. Histologically, the growth is to be compared to an angiosarcoma, and its cause is possibly that underlying tumor formation in general, and due to some congenital condition of the vessels. Darier, from his investigations of the case in question, proposes the name Sarcome Angioplastique Réticulé. He considers that we have to do with a peculiar form of sarcoma which is not massed to form a single tumor, but has a reticulated structure following the vessels of the skin, and that there is a tendency to form clusters of capillaries, approaching in this way the characteristics of a true angioma. He refers to the fact that in some of the soft nævi cell forms are found very similar to those of this case.

The number of reported cases of this disease is too small to warrant any general conclusions as to its course. In Hutchinson's case there was a recurrence of the growth after cauterization. In White's case the nodular infiltration made its appearance in the normal skin beyond the scar left from cauterization. This patient was seen six years later, when he had reached the age of eighteen. There had been some treatment by cauterization in the mean time, and again the appearance of lesions jumping over the part treated, to reappear beyond the cicatrix in the sound tissue, was seen. There had been no breaking down in any part, and on the whole it seemed as if the process was gradually becoming less active.

Treatment of this affection has thus far proved most unsatisfactory. Caustics or excision may convert the territory occupied by the lesions into a cicatrix, but hitherto they have failed to stop the peripheral spread of the disorder, and sometimes new lesions have recurred in the scar tissue itself. Electrolysis applied along the edges that are progressing has been advocated, but no successful results from this or any other method of destruction have been reported. *John T. Bowen.*

ANGIONEUROTIC ŒDEMA.—DEFINITION.—A vasomotor neurosis or an angioneurosis, characterized by the appearance of circumscribed swellings on various portions of the surface of the body and the mucous membranes, by preference the face, throat, and extremities, without apparent cause or premonition, and non-inflammatory in character.

SYNONYMS.—Acute circumscribed œdema; acute idiopathic œdema; periodic swelling; urticaria tuberosa, or giant swelling; acute non-inflammatory œdema; Australian blight.

HISTORY.—Although references to this affection may be found here and there in medical literature since 1827, it is only during the present generation that it has been recognized as a disease possessing sufficient individual characteristics to have a history and special designation of its own. It is to Quincke, and his pupil, Dinkelacker, that we are indebted for calling the attention of the profession to this disease in such a lucid manner that it was soon generally recognized.

ETIOLOGY.—*Age.*—The period of early life furnishes the greatest number of cases, the average age in a series of ninety-three cases examined by the author being twenty-four. It rarely occurs for the first time in individuals upward of sixty years of age. Childhood, however, is by no means exempt; a case is reported by Dinkelacker, in which a child, whose father suffered from the disease, had an attack for the first time when it was three months old.

Sex.—It occurs oftener in males than in females. The disorder is seen just as often in women as in men when the former are exposed to conditions that produce bodily and mental exhaustion.

Heredity.—This is one of the most important and interesting elements in the genesis of the disease. It has been seen to occur in families one generation after another. In a remarkable series, reported by Osler, the disease was demonstrated to be present in five generations, including in that time twenty individuals. Its occurrence in several members of one family has recently been reported by Meige.

Previous and Present Condition of Bodily Health.—No relationship can be traced to previous, immediate, or remote disease, and the majority of cases presenting themselves with this disease are in fairly good health. It

occurs in neuropathic individuals and occasionally in those who suffer from hysteria, neurasthenia, and Graves' disease.

Exciting Causes.—Of the directly exciting causes, cold, traumatism, and psychical disturbances are the most obvious. Fright, grief, anxiety, worry, and the ingestion of certain kinds of food, such as apples and fish, have all been found to be exciting causes in some patients. The relationship of an attack to the use of alcoholic liquors and tobacco can sometimes be made out. An attack is often precipitated by cold, as in passing from a warm into a cold atmosphere, although it does result after severe muscular exercise with consequent sweating and then becoming cool very rapidly. In women attacks are most liable to occur during or near the menstrual period. The period in the twenty-four hours when attacks are most liable to show themselves is during the time between 1 and 5 A.M., when the tide of life is at its lowest ebb and the parts are least resistant.

Area of Distribution and Primary Point of Manifestation.—In a total of 83 cases the swelling showed itself for the first time: in the face in 33 cases; on the extremities in 24; in the pharynx, uvula, and larynx in 6; on the genitals, penis, and scrotum in 6; on the body in 6; on the gums and palate in 2; in the stomach in 4; on the neck in 1; and behind the ears in 1. Of the cases in which the swelling showed itself upon the face, in 5 it was restricted to the forehead; in 3 it occurred first on the eyelids, in 9 on the lips, and in the remainder it was distributed over various portions of the face. Of the extremities, the hands were by far the most often attacked, and after these the forearms were the next most frequent seat. The occasional occurrence of this variety of œdema in the gastro-intestinal mucous membrane seems to be sufficiently attested by characteristic symptoms.

The occurrence of the swelling in one spot seems to predispose the place for future attacks, and it is the exception for it to be once seen in a place which thereafter remains free. Parts of the body which have received injury or have been the seat of protracted pain seem occasionally to be favorite places for the development of the swellings. Occasionally there seems to be a periodicity in the appearance of the swelling. It has been contended that the pia, and even the brain substance itself, may be the seat of this variety of œdema. No proof of such occurrence has been given, and the only testimony is inferential from certain rather obscure clinical data.

SYMPTOMATOLOGY AND CLINICAL COURSE.—The manifestations of the disease generally present themselves without warning, and the suddenness of their appearance and departure is rather characteristic. Possibly the patient may complain, for a short time before the appearance of the swelling, of vague feelings of malaise, general disinclination to do anything, and a feeling of depression associated with ill-defined gastro-intestinal symptoms. The œdema comes on quickly, generally reaching its full development in a few hours, and gives the patient very little trouble, except by its mere presence; there is a feeling of stiffness and unwieldiness and a sensation as if the parts were on the stretch, but this sensation is not attended with pain or distressing throbbing, or any of the subjective symptoms of inflammatory swelling. The swelling is distinctly circumscribed and plainly differentiated from the surrounding surface, and of varying color. In some cases, but probably not in the majority of them, the skin is of a dark-red, dull roseate hue, while in others the marked contrast between the pale, almost waxy color of the swollen surface and the skin around it is very striking. The œdematous part does not pit on pressure, or if it does, only in a few cases, and in these not to any marked extent, so that the indentation produced by the forcible pressure of the finger is quickly effaced.

The subjective symptom of which the patients complain most is a sensation of scalding or burning during the occurrence of the swelling, this being probably due to the marked tension under which the skin is suddenly placed; and after this, there is generally a feeling of itchiness. Outside of these, if the swelling does not encroach on any organ, such as the eye, the stomach, the penis, and the testicles, or does not block up the conductivity of a passage, such as the pharynx or larynx, as it sometimes does, and so produce trouble, it is not likely that the patient will complain of any other subjective symptoms. Frequently the surface temperature of the swollen part has been found to be slightly elevated, while, on the other hand, carefully made observations have demonstrated that the specific heat of these parts is considerably lowered. It is probable that at the beginning of an attack the surface temperature of the part is somewhat elevated, while later, or just before the swelling begins to wane, the temperature falls.

The swelling generally reaches its height in any one part in a few hours after its appearance, in some cases in a few minutes, while in others from six to eight hours will elapse. After remaining for a period varying from a few hours to days, it will begin to disappear, ordinarily with a rapidity corresponding to that with which it showed itself. Frequently its disappearance from one part is the signal for its appearance in another, which may have no anatomical or physiological relation to the part previously affected. As a rule it does not show itself in more than two or three localities at one visitation, and frequently only in one. The disease recurs, and in the analysis of the cases spoken of above, the time between the attacks averaged twenty-one days. Occasionally a patient will have three or four attacks in a month, while others go for three and four months, and even longer, before they have a recurrence. Just before and during an attack the patient is often depressed, anxious, afflicted with forebodings of evil or calamity similar to those of neurasthenia. I have noted these psychical or emotional symptoms peculiarly in those in whom excessive use of tobacco and alcohol seemed to have something to do with causing the condition.

The symptoms of the disease when some of the mucous membranes are attacked are well marked and suggestive. As has already been said, the mucous surfaces most often attacked are those of the stomach and of the larynx. In about one-third of the cases gastro-intestinal symptoms are prominent. These symptoms are first a feeling of uneasiness and tension, as if something indigestible had been taken and had remained in the stomach. With this there is loss of appetite generally associated with constipation, which is soon followed by a distended appearance of the epigastrium; and then follows a sharp colicky pain, often attended with profuse vomiting and great thirst. The pain may be so severe as to demand the administration of morphine. The character of the material vomited consists at first of the contents of the stomach, but later it becomes watery and somewhat stringy from the mucus which it contains, and it is frequently profuse in quantity. When this continues for any length of time the thirst becomes greater, and large quantities of urine are frequently passed, which, however, contain nothing abnormal with the exception of increased amounts of earthy phosphates. Transient hæmoglobinuria has been noted in two or three cases. After this exacerbation in the symptoms has ceased, the reaction sets in, and there is frequently diarrhœa of a colliquative nature, with an apparent retraction of the abdomen and a general feeling of lassitude and prostration, and the characteristic symptom of the disease shows itself in another part of the body, or, if it has already done so, it now begins to disappear.

When the swelling appears in the larynx, it of course produces symptoms in proportion to the amount of encroachment that it makes. This is often so great as to cause distressing symptoms of suffocation, and, indeed, in some instances death has taken place in consequence of the œdema. In others the symptoms are so severe as to demand liberal scarification, or, more rarely, tracheotomy. As a rule the swelling does not pass by continuity from the pharynx to the larynx, but when the latter region is affected by the disease the swelling develops there with the same degree of abruptness and vigor as in other

parts of the body, and in consequence the horrible sensation of choking to death is added to the patient's misery. Difficulty in swallowing, when the seat of swelling is in the pharynx, is not so common as the corresponding symptom of difficulty in breathing, which occurs when the larynx is the seat of the disease, nor does it ever become so distressing. If it be granted that the œdema in question may manifest itself in the lungs, as many good observers would have us believe, the symptoms resulting will not differ materially from those of acute pulmonary œdema, except in the suddenness of onset, the urgency of the symptoms, and the abrupt mode of departure.

Of the general health between the attacks but little need be said. Generally there is nothing noticeably wrong, although for a day or two after an attack there may be a feeling of prostration, especially if the gastric or intestinal mucous membrane has been attacked; but this soon passes away, and the patient's physical condition and his morale are excellent until the next attack shows itself. Frequently there is not even this feeling of lassitude.

Diagnosis.—The diagnosis of a case of angioneurotic œdema will be attended with little or no difficulty if arrived at by the process of exclusion. The spontaneous appearance of the œdema, its recurrence at certain intervals, the absence of the concomitant symptoms of inflammation, either local or constitutional, and the abruptness of the disappearance of the œdema, are generally sufficient to enable us to recognize the disease at once.

It may be confounded with the blue œdema of hysteria, as described by Sydenham, or with the white œdematous swellings that sometimes occur with the same disease, as described by Charcot. Such confusion is of no moment, however, as the pathogenesis of the swelling is probably the same in both cases. Moreover, the treatment for the one is appropriate for the other. In hysteria, however, and especially if the hysterical attack is sufficiently profound to have œdema as one of its attendants, there will always be found the well-known stigmata which will be sufficient to make the diagnosis. Other factors, such as the abruptness of onset and the mode of departure, as well as the distribution of swelling in angioneurotic œdema, will corroborate the diagnosis.

There are a certain number of affections described under other names which are in all probability modified forms of this disease. They are urticaria tuberosa, Australian blight, malarial œdema, acute essential œdema, creeping œdema, ephemeral congestive cutaneous tremors. As was seen at the beginning of this article, these terms are considered as synonyms of the disease in question, and therefore require no further description.

Duration and Prognosis.—The duration of the disease varies from a period sufficient for one attack to a lifetime; the duration of the attack, from one hour to a week. The statistics bearing on prognosis do not allow us to draw conclusions that are of any great value, on account of the fact that the patients do not often remain under the physician's care sufficiently long to enable him to study the natural course and termination of the disease. I am inclined to believe that in about half the instances the disease disappears after lasting a variable length of time, say from two to three years. In the other half it may remain dormant for prolonged periods, but one can never prognosticate when or where it is next going to manifest itself. In this respect it resembles all other manifestations of the neuropathic state, as well as the neuroses, hysteria, and neurasthenia which it sometimes accompanies. In still other cases it continues to recur with varying intervals during the patient's entire life, which may not, however, be perceptibly shortened by the exhibition of these attacks. Not infrequently the manifestations cease to present themselves when the exciting cause is obviated. The disease rarely causes death, and then only when laryngeal involvement is so profound as to cause suffocation. Whether or not the possession of this infirmity tends to shorten life by predisposing to other conditions which jeopardize the life of the patient, nothing definite has been observed, and there must necessarily be many observations before any justifiable conclusions can be drawn in regard to this point.

Pathology.—The pathology of the disease is still rather obscure. The nature of the lesion is unquestionably that of a non-inflammatory œdema circumscribed in form. The fact that the epidermis is not involved is decidedly opposed to the view that the lesion is an inflammatory one, even though it is not so evident clinically that the œdema is in no way connected with an inflammatory condition. The seat of the œdema is usually in the connective tissue of the derma, beneath the papillæ, and in the subdermal tissue; very rarely the œdema confines itself to the more superficial parts. It is probable that although the lesions or the irritants on which the disease is dependent may attack the other parts of the system, yet the result directly appears through the sympathetic system of nerves. Furthermore, the nerves affected are undoubtedly the vasomotor nerves. The pathogenesis of the disease has a close relation to other vasomotor neuroses, such as morbid blushing and flushing, exophthalmic goitre, the so-called pulsating variety of neurasthenia, and intermittent swelling of the knee, and to some of the arthropathies as yet not well understood. An œdema very similar to it is occasionally associated with tic douloureux, migraine, and nerve-stretching, and in hypnotizable subjects it is apt to follow a séance.

Treatment.—Therapeutic measures are of little avail, either in mitigating the length or the severity of the attack or in increasing the intervals between their occurrence. A fact that the practitioner will do well to bear in mind when called upon to treat any neurosis which is apparently dependent upon perversion of function of the sympathetic nervous system, is that disease thus originating is far less amenable to therapeutic agencies than when it is dependent upon some lesion of the cerebro-spinal system. The greatest success will be obtained by adopting such hydriatic, hygienic, dietetic, disciplinary, and medicinal measures as give tone and stability to the nervous system. As an all-round vasomotor and general tonic to the nervous systems of the body strychnine most nearly reaches the mark. It should be given in large doses and until its full physiological effects are manifest, particularly on the spinal cord; for although the affection is one indicating defect in the sympathetic nervous system, we must not forget that the origin of that system is in close relation genetically with the spinal cord. Physostigmine salicylate, in from gr. $\frac{1}{60}$ to gr. $\frac{1}{30}$ doses, is often beneficial. The next most important drug in the treatment is atropine; it should be likewise given in moderately large doses, and its administration should be continued during the intervals between the attacks. Tonics, invigorating baths, exercise, massage, and the prevention of trauma are the most important factors in the treatment of this disease. It is unnecessary to enter into details concerning the treatment for symptoms as they arise. If there be an excess of uric acid in the blood, manifest by a disproportionate relation to the urea in the urine, this condition demands regulating. The same may be said of constipation, menstrual irregularities, and the like. The treatment at the time of an attack will depend somewhat on the part of the body in which the disease is manifest. If the dermal surface of the body be involved, the most satisfactory plan of treatment is to keep the patient quiet, in an equable temperature, and to apply dry heat to the swelling; and if there be much uneasiness or restlessness, a mild anodyne should be administered. Compression by means of a bandage or a Gamgee dressing is occasionally of benefit. When the disease manifests itself in the mucous membranes the treatment is entirely symptomatic. As I have already stated, when the gastro-intestinal symptoms are prominent, morphine fulfils two conditions: it relieves the severe pain and distention, and checks the vomiting for the time being. When the disease shows itself in the throat and larynx, this drug should not be given unless the pain is so severe as urgently to demand its employment. It will occasionally be necessary to scarify and sometimes, but rarely, to perform the opera-

tion of laryngotomy. It need scarcely be emphasized that when either of these procedures is indicated it should be done at once. In every case it will be wise to begin treatment with the administration of calomel followed by a saline. Oftentimes this, with a judicious regulation of the diet and the administration of a suitable mineral water to counteract any diathetic tendency, will be all that is required. The use of electricity, although recommended, has not been attended with sufficient success to warrant more than mere mention. *Joseph Collins.*

ANGIOSARCOMA. See *Sarcoma.*

ANGUILLULA INTESTINALIS. See *Nematoda.*

ANGUILLULA STERCORALIS. See *Nematoda.*

ANGUSTURA.—Cusparia. The bark of *Galipea Cusparia* A. St. Hil. (fam. *Rutaceæ*). This is a shrub or small tree of the Orinoco River valley, exported from Bolivar. The river at this place runs in a narrow channel, called "*Angustura*" (equivalent to "The Narrows"), and this has given its name to the bark. The bark was formerly shaved off in long strips, often with wood adhering to the inner surface. More care is now taken to obtain it in quills, which, however, arrive much broken up into curved or quilled pieces. Its outer surface presents a peculiar and very characteristic appearance, being of a yellow-clay color and densely covered with small and very slightly elevated scale-like warts, which can be readily scraped off with the finger nail. It rarely reaches a fourth of an inch in thickness. The inner surface is usually marked by a transversely wavy appearance. It has a short and sharp, but by no means weak, fracture, which discloses a zone of stone cells between the periderm and inner bark and darker volatile-oil cells. It is very bitter and aromatic. Its composition indicates properties of greater importance than have yet been attributed to it. Volatile oil, to the extent of from 0.5 to 1.5 per cent., gives its aromatic, and a considerable amount of the amaroid *angusturin* its bitter properties. With these, a peculiar resin and a little gum, occur the alkaloids *galipine*, *galipinine*, *cusparine*, and *cusparidine*, all crystallizable. The chief consumption of angustura is in South America and the West Indies, where it is highly valued as an antiperiodic and intestinal stimulant. Its use in the United States, outside of patent medicines, has been as an aromatic bitter. The dose is 0.6 to 3 gm. (gr. x.-xlv.). Large doses have a purgative effect. *H. H. Rusby.*

ANHALONIUM. See *Muscale Buttons.*

ANHYDROTICS. See *Antisudorifics.*

ANIDROSIS.—Anidrosis in the usual meaning of the term denotes a disturbance of the function of the perspiratory glands in which their secretion is either absent or materially diminished. Under these circumstances the skin is dry and harsh, more or less pruritic, and inclined to crack or fissure. Cold lessens the amount of perspiration and heat increases it, and this increase or diminution in the amount of sweat is also influenced by certain drugs which may be readily called to mind. The close connection between the several functions of the kidneys, bowels, and skin may also be mentioned. Certain persons normally sweat but little, even under conditions that ordinarily provoke the secretion, as, for example, in the Turkish bath.

Anidrosis is usually symptomatic, and is accordingly observed in connection with some general or local pathological condition. A general diminution of sweat is frequently seen in diabetes mellitus and insipidus, and in the states of malnutrition dependent upon tuberculosis and the cancerous cachexia. Sweating is apparently absent in the patches of anæsthetic leprosy and in localized areas in scleroderma, psoriasis, and eczema. The ichthyotic notably suffer in this way. Aubert has made an extended study of the secretion of sweat in various diseases of the skin, to which the curious reader may be referred (*Ann. de derm. et de syph.*, tome ix., 1877-78). The association of anidrosis with various disorders of the nervous system, and as following direct nerve injury, etc., may also be referred to in this place. Lastly, deficient perspiration may be due to simple mechanical plugging of the sweat ducts, the result of uncleanliness. Kaposi declares that there is no absolute anidrosis, the insensible perspiration never becoming abolished. This, he states, becomes noticeable as a fluid secretion whenever the skin, however dry it may feel, or even if affected with one of the dry dermatoses (psoriasis, ichthyosis, prurigo), is covered with some material that prevents evaporation. It is certainly true, however, that under certain circumstances, and in limited areas, the sweat glands may be entirely destroyed or undergo atrophy from a variety of causes, or that paralytic conditions arise in consequence of nerve lesions due to the presence of new formations (Geber).

The prognosis and treatment must be based upon the character of the primary cause. In a general way it may be said that the skin should be stimulated by warm alkaline baths and massage. Pilocarpine gives only temporary relief. Cod-liver oil and glycerin are often prescribed in considerable doses. Unna recommends arsenic and ichthyol separately or together. Free lubrication with fats gives much comfort in ichthyosis.

William A. Hardaway.

ANILINE.—(*Amidobenzene, Phenylamine,* C_6H_7N.) Aniline is an aromatic amine presenting itself as a thin, oily, colorless fluid of a vinous odor and hot, aromatic taste. It is very volatile and inflammable, dissolves only very slightly in cold water, but freely in alcohol, ether, fixed and volatile oils, etc. It is remarkable for the great number of colored crystallizable compounds that it forms with acids. Physiologically, aniline is a powerful neurotic of more interest toxicologically than therapeutically. Experiments upon animals show serious derangement of the functions of the spinal cord as the essential element of the aniline action. The aniline dye stuffs are certainly, in the great majority of instances, not themselves poisonous, but in the form in which they are in some cases practically used they may poison, because of the presence in them either of uncombined aniline or of arsenic. Many of the cases of eczema following the wearing of aniline-dyed shirts or stockings have doubtless their cause in such contamination of the dye.

Therapeutically aniline has been experimented with, to a small extent, in some nerve diseases, notably chorea and epilepsy, and in scarlatinal dropsy. Aniline has been given in doses of a grain or two, and aniline sulphate in doses of five grains or more. *Edward Curtis.*

ANILIPYRINE is a combination of one equivalent of acetanilid with two equivalents of antipyrine, and it appears as a crystalline white powder which is fairly soluble in water. It combines the antipyretic and analgesic properties of its components, and is claimed to be less toxic than either. Its dose is gr. v. to x.

W. A. Bastedo.

ANISE, ANISUM.—*Anise Fruit.* "The fruit of *Pimpinella Anisum* L. (fam. *Umbelliferæ*)" (U. S. P.). The anise plant is a small annual, from 30 to 50 cm. high (twelve to twenty inches), a native of the Orient, but so long under cultivation that its wild form and original home are scarcely known. It is a long-known drug, mentioned by the earliest writers on medicine, and referred to as a medicine or spice in nearly every period since then. It has been cultivated in the warmer parts of Europe, Asia Minor, Egypt, Russia, and Africa for centuries; more recently also in India and South America. The principal supply comes from Southern Europe.

The mericarps are rather loosely attached together. In many such fruits these fall apart upon ripening, but not in anise, where they are always adherent. The whole

fruit, so formed, is small, hard, ovoid, seed-like, and finely bristly pubescent. It has a grayish-green color and strong, agreeable odor. A transverse section is nearly circular in general outline, with ten projecting ribs. The *Vittæ* are numerous, two or three times as many as the ribs, and are rather small. The seed on section is somewhat crescentic. Anise is apt to be pretty dusty, and is mixed with stems and various coarse impurities, requiring frequently to be winnowed or sifted, but it is not often adulterated. In one instance, many years ago, serious trouble was caused on account of its being mixed with conium.

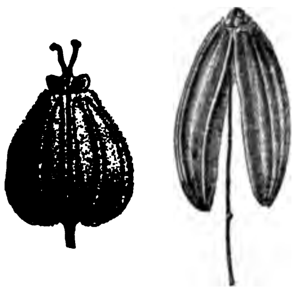


FIG. 208.—Anise, Enlarged About Six Times.

The properties and uses of anise are wholly those of anethol, which constitutes about ninety per cent. of its one and one-half to three per cent. of volatile oil. It contains also a rather larger amount of fixed oil and a little gum and sugar. The dose is 0.5 to 2 gm. (gr. viij.–xxx.). Excepting the oil, there is no official preparation.

Oil of Anise.—A volatile oil distilled from anise. It is colorless or pale yellow, of characteristic odor and taste, has a specific gravity of 0.980 to 0.990 at 17° C., and rotates very slightly to the left. At a temperature of from 14° to 19° C. it congeals. More than ninety per cent. of it is anethol, which gives its properties, and which may the more advantageously be employed, as uniformity is thus secured. It belongs to the more carminative class of volatile oils, and shares the diffusive stimulant properties of volatile oils in general. It is, at the same time, of an unusually pleasant flavor and much used for purely flavoring purposes, especially as an addition to liquors. Its pleasant flavor also makes it of special use in treating the flatulent colic of infants, and in adding to medicines which have a tendency to gripe. The dose is ♏ iij. to xv. The official preparations are the Aqua, of one-fifth of one per cent. strength, and the Spiritus, of ten-per cent. strength. The Sp. Aurant. Comp. contains one-half of one per cent., and the Tincture Op. Camph. two-fifths of one per cent. It also flavors several other preparations.

Anethol ($C_{10}H_{12}O$).—The active constituent of oil of anise, of which it constitutes about ninety per cent., of oil of star anise, which contains somewhat less of it, and of oil of fennel, which contains about sixty per cent. of it. It occurs both as a solid and as a liquid, the former in colorless crystalline plates. Its specific gravity at 25° C. is 0.985, and it melts at 21° to 22° C. It is freely soluble in alcohol and slowly in water. Its odor and taste are purely those of anise, and it may be used with advantage in doses of one to ten grains as a substitute for the above named oils. *H. H. Rusby.*

ANISE, STAR.—*Illicium.* "The fruit of *Illicium verum* Hook. (fam. *Magnoliaceæ*)" (U. S. P.). The species here named is the Chinese, or sweet star anise, besides which there is a poisonous Japanese species. When Linné applied the name *I. anisatum*, supposing that he had the former, he really had the latter, as his description and figure clearly show. As a result of this mistake, the poisonous species must always bear the inappropriate name *I. anisatum* L. (Syn.: *I. religiosum* Zucc.), and Hooker's later name, *I. verum*, must pertain to the useful species.

The plant is a handsome small tree.

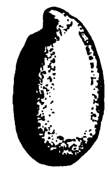
The fruit consists of the eight carpels, united to a carpophore, from which they can be easily separated, but distinct from one another. Each carpel is short, laterally compressed, "boat-shaped," pointed at the upper and outer extremity, and dehiscent at the upper and inner border. The pericarp is deep brown, rather woody, brittle, fragrant, and spicy. The seeds, which can be seen through the split in the carpel, although this is not usually wide enough to let them fall out, are also brown, but very smooth and shining. They are less fragrant than the carpels, but contain considerable fixed oil in their kernels. Both testa and pericarp show, under the microscope, numerous oil cells, and the parenchyma of the seeds reveals drops of fat.

COMPOSITION.—Besides sugar, gum, and oil, which, although abundant, have no practical value, star anise is remarkable for containing a large percentage (from three to five) of an essential oil, so similar in odor, taste, properties, and composition to that of anise, that no means can be relied upon to distinguish them from each other, except by the greater percentage of anethol in the latter, on account of which it congeals at a higher temperature.

FIG. 209.

FIG. 211.

FIG. 210.



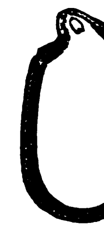


FIG. 212. FIG. 213.

FIG. 209.—Illicium verum, Flower. FIGS. 210 and 211.—Gynæcium and fruit. FIGS. 212 AND 213.—Seed, entire and in longitudinal section. (After Baillon.)

Illicium is never prescribed, and is recognized only as a commercial source of "oil of anise." This oil, owing to its weaker action, should not be indiscriminately substituted for oil of anise. *H. H. Rusby.*

ANKLE JOINT.—As this joint supports the weight of the body, considerable stability is required of it. This is secured mainly by the shape of the articular surfaces, which interlock like a mortise and tenon. The tibia and

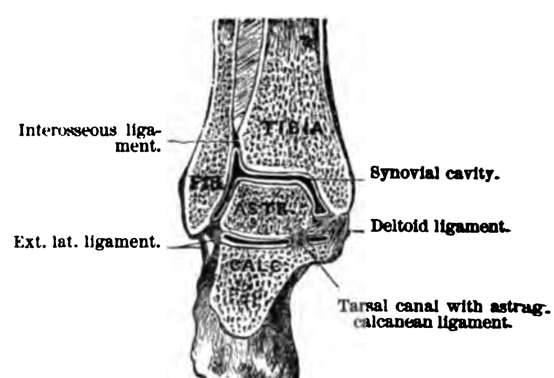


FIG. 214.—Frontal Section of Right Ankle.

fibula, strongly united by ligaments (interosseous and inferior tibio-fibular, Figs. 214, 215, and 218), form the mortise by embracing with their extremities (malleoli) the tenon-like astragalus. The joint is a hinge, its movement angular, and in a single oblique plane (corresponding to the outward pointing of the toes) through an arc of some eighty degrees. In the fœtus of six weeks (Henke and Reyher) the joint is arranged like that of

some marsupials, so as to admit of rotation, the astragalus sending a process up between the tibia and fibula. A trace of this movement remains in the adult. To

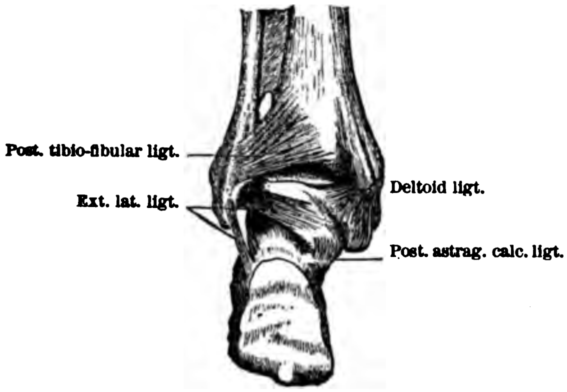


FIG. 215.—Rear View of Left Ankle.

guard against the thrust of the tibia and fibula when alighting on the extended toes (the commonest form of

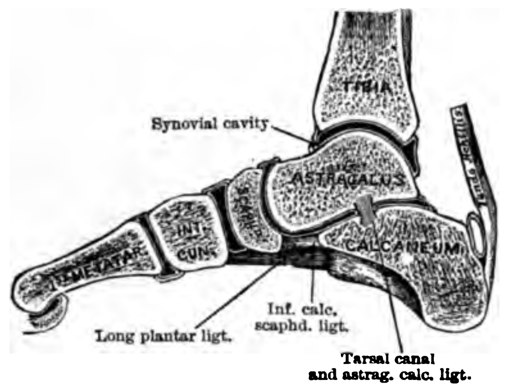


FIG. 216.—Sagittal Section of Right Ankle.

dislocation arises thus), the astragalus is narrower behind than in front, averaging 35 mm. behind and 40 mm. in front. And a slight lateral movement is therefore possible when the malleoli are thrown back in complete extension. The malleoli are held against the articular surfaces in all positions by the elasticity of the shaft of the fibula, which bends inward when the wedge pushes the malleoli apart, springing back during extension. The axis of rotation of the curved superior surface of the astragalus (Fig. 216)

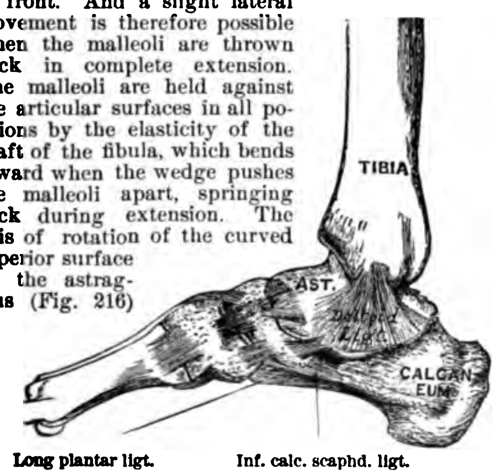


FIG. 217.—Inner Side of Right Ankle.

passes through the most fixed part of the bone, viz., the tarsal canal, touching the outer malleolus but passing below the inner, which does not descend so low (Figs. 214 and 215). The original capsular ligament (see *Arthrology*) remains in front and behind as a thin layer of fibres connected with the synovial membrane and strengthened by the extensor tendons in front and the tendon of the flexor longus hallucis behind. Effusion into the joint usually shows first in front. On the sides strong bands are developed. The internal lateral ligament (Figs. 214, 215, and 217), also called the deltoid, from its triangular form, is the strongest of these; in dislocations usually tearing the bone apart. It is a thick bundle, ensheathing the internal malleolus and passing to the calcaneum, the scaphoid, and the calcaneo-scaphoid ligament. The tendon of the tibialis posticus strengthens it. Deeper fibres pass to the astragalus. In amputating at the ankle the joint is opened on the inner side, because of the shortness of the malleolus, and the existence of this deep band

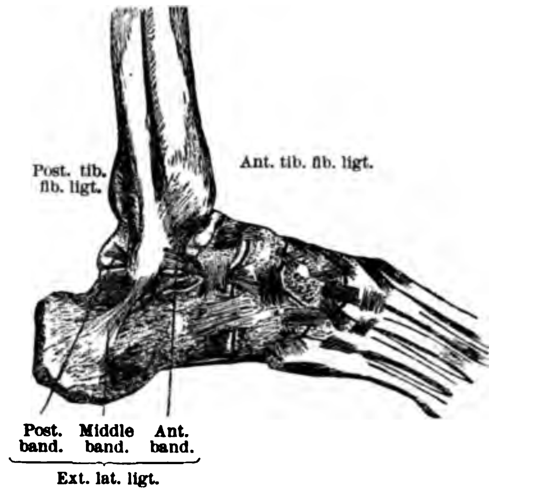


FIG. 218.—Outer Side of Right Ankle.

should be remembered. The external lateral ligament (Figs. 214, 215, and 218) is composed of three bands which radiate from the lower part of the malleolus, the anterior and posterior bands passing to the astragalus, the middle one to the calcaneum. The synovial cavity is quite extensive, communicating above with the inferior tibio-fibular articulation. It is said to contain more synovia than that of any other joint (Morris). Its capacity is not affected by the position of the foot, and no change of posture takes place during inflammation of its membrane.

Sensations of pain are sometimes felt in the ankle without lesion of the joint, caused by some injury to the long nervous trunks which supply it, viz., the long saphenous, connected with the lumbar plexus, and the anterior tibial with the sacral plexus. The vascular supply arising from twigs from the anterior and posterior tibial arteries, and discharging by both saphenous veins, may be interfered with by tight boot laces and occasion a dull pain. *Frank Baker.*

ANKYLOSIS (sometimes spelled anchylosis).—"(ἀγκύλος, a stiff joint). Union of the bones forming a joint, resulting in a stiff joint. Ankylosis, false or spurious, is due to the rigidity of surrounding parts. Ankylosis, true or bony, is the proper term to employ when the connecting material is bone; and ankylosis ligamentous, when the medium is fibrous" (Gould's Medical Dictionary, 1897).

SYNONYMS.—English: Stiff joint, fixed joint; French: Roideur articulaire, Anchylose; German: Gelenkverwachsung, Gelenksteifigkeit; Italian: Anchilosi; Latin: Ankylosis cartilaginea, Ankylosis fibrosa intercartilaginea, Ankylosis fibrosa interossea, Ankylosis ossea.

A strictly correct definition would designate a fixed angular position of a joint, but this restriction no longer obtains, the word now being used to describe joints, in whatever position, that have become more or less stiff.

Qualifying terms are used to indicate the extent of the stiffness, such as false, spurious, true, bony, ligamentous, partial, complete, incomplete, etc., all of which can be best understood with the least possible confusion if the word ankylosis is accepted as a synonym for stiffness.

Etiology.—Traumatism, gonorrhœal rheumatism, suppuration in joints, tuberculous osteitis, tuberculous synovitis, syphilitic affections of joints, long fixation when a fracture is near or extends into a joint, osteitis deformans, etc.

Pathology.—In complete, *i.e.*, bony, ankylosis the bones forming a joint are limited by callus in the same manner that union takes place after a fracture in the shaft of a long bone, or bridging by callus takes place at one or more places around the joint. Usually osseous ankylosis is preceded by a more or less prolonged stage of fibrous or cartilaginous union. In fibrous ankylosis bands of fibrous connective tissue unite the bones forming a joint, thereby limiting the motion. Accordingly as these bands are short or long the stiffness is complete or partial.

In cases of joint stiffness produced by extra-articular, fibrous, tendinous, or cicatricial contracture the joint remains free from adhesions for years when it has not been involved in inflammatory action.

Diagnosis of bony ankylosis is usually unattended with difficulty except where there are a number of joints near together, as, for example, the carpus, tarsus, and spine. This limitation of motion in one joint is generally compensated for by excess of motion in another, thereby rendering all the surrounding parts capable of functionating in a very nearly normal manner.

Fibrous ankylosis is more difficult to discern, especially if pain accompanies the required manipulative procedures. It is most apt to be confused with fibrous, ligamentous, or cicatricial contractures of soft parts outside of a joint, but having direct functional relations therewith. Extra-articular contractions may often be differentiated by the existence of resistance to free joint motion in one direction only, *i.e.*, that produced by the contracture, while the joint moves more or less freely in other directions. Muscular contracture, whether voluntary or involuntary, is but temporary, and the rigidity of the surrounding parts is clearly discernible.

As muscular rigidity is one of the most important and reliable symptoms of joint inflammation, it is a serious error to anæsthetize a patient for examination of a joint until the absence of muscular fixation has been clearly proven. In such cases the anæsthetic relaxes the muscles, leaving the joint free for movements which are seriously prejudicial and which were instinctively guarded against by the patient.

If there has been no muscular fixation much may be learned by the careful study of a joint while the patient is unconscious. It can be definitely determined whether it is ankylosed or only partially so. The yielding of the soft parts above and below the joint suspected may be prevented by tightly bandaging them, the joint itself being left uncovered.

Treatment.—The most important part of the treatment lies in prophylaxis, prevention of the occurrence of ankylosis, or, if it is inevitable, in so disposing the parts that the best position for future usefulness may be obtained. The trend of modern surgery is greatly to shorten the time of fixation of a fractured bone, in the effort to avoid impaired joint function, as well as to secure a freedom from muscle atrophy. The earlier application of passive motion and massage is being resorted to, and many of the serious deformities which formerly followed fractures are now less frequently seen.

Each individual joint has special features and presents special difficulties that must be carefully considered in applying any form of treatment. The most useful position for a stiff joint is still subject to discussion; no general rule can be laid down. Fibrous or incomplete ankylosis may require attention to overcome a faulty position, or to increase the extent of the motion. This is to be accomplished by passive motion made in the direction of the normal action of that joint. Brisement forcé is a term applied to the use of such force as the surgeon can judiciously apply, bearing in mind the danger of breaking the shaft of the bone used as a lever or of producing a separation of the epiphysis. It is wise to begin all manipulations well within a safe limit, and gradually to increase the power employed as the range of motion increases; remembering that the strength of the long bones often diminishes from disuse and that they will break if a sudden corrective force is applied. The above methods are greatly facilitated by previously subjecting the limb to dry hot air at a temperature of from 300° to 400° F. for an hour. For this purpose some one of the many forms of ovens made for the purpose may be employed. Care should always be taken to wrap thoroughly the parts in flannel, but never in cotton. The latter is highly inflammable and holds the moisture. The interior of the oven should be kept as dry as possible, as the perspiration, which is often profuse, renders the atmosphere within the oven moist, and is apt to result in scalding the patient.

Ovens are now made for use with alcohol, gas, and electricity as means of generating heat. Each has its peculiar advantages, but the results are not different. The effect is to soften the fibrous adhesions very much in the same way that old glued joints of wood are softened, enabling the surgeon to obtain movements of a partially stiff joint with very much less force and therefore with less danger and less pain.

The pain accompanying corrective manipulations following the use of the oven is generally inconsiderable, although varying greatly in different subjects. When the pain is very great, the employment of an anæsthetic that acts quickly enables the operator to proceed with greater despatch. The anæsthetic that I have found most satisfactory for this purpose is ethyl bromide. I have also used chloroform and at times nitrous oxide gas.

Fixation appliances of any kind are contraindicated during corrective procedures in fibrous ankylosis, as increased freedom of movements is desired rather than fixation. Voluntary motions are to be encouraged to increase the mobility and to regain the muscle function which is required for proper use of the joint.

The employment of electricity has been extolled for its effect in restoring lost or impaired muscle function, and when used by skilful physicians it is more likely to produce the desired effects than when crudely applied by a more or less non-medical attendant.

Massage is a means of restoring impaired muscle power that should not be overlooked, and, like all other therapeutic measures, should be carefully prescribed as to methods and time. The object sought should be the voluntary control of the affected joint and the mechanism that actuates it: this should be impressed on the patient.

In true ankylosis the object sought is the most useful position of the parts, and here careful study is necessary to avoid attempting to obtain a movable joint when greater usefulness could be had from a stiff joint in an approved position. The greatest diversity of opinion exists as to the most desirable position for ankylosed joints. In the elbow a fully extended position of the arm is generally conceded to be the least useful, while the exact angle of flexion has been the cause of much discussion. Some advocate a right angle, others a lesser angle, to enable the patient to bring the hand to the mouth; and yet any rigid position is more or less conspicuous and cumbersome.

The hip when ankylosed at various angles can be made useful by the increased latitude of motion imparted to the other hip joint and to the lumbar vertebral articulations. To such an extent is the lower spine reciprocal in loss of function of one or both hip joints that it has been called the third hip joint. Ankylosis of a hip at right angle to its fully extended position has frequently been observed to be useful for progression. The third hip joint has also developed in efficiency in cases in which a hip joint was ankylosed in the most approved position, *i.e.* that of almost full extension, facilitating the move-

ments of the entire pelvis in walking and especially in sitting, and approaching very closely normal action.

The arguments in favor of a fully extended leg versus slight flexion in cases of bony ankylosis of the knee appear to be about equally divided. The slightly flexed leg is certainly somewhat less in the way in sitting, and it enables the patient to develop a more graceful carriage, but all of these are cast into insignificance by the mechanically faulty position of flexion. Ashhurst refers to a case in which the knee remained straight with apparent bony union for eight years and then began to yield, and within a year was bent to a right angle and rotated. The fully extended or straight position is less liable to bend because its weight-bearing function is disposed in the mechanical position in which it was designed to act most efficiently. Where the quadriceps attachment to the tibia is maintained or properly substituted, the powerful flexors will have less opportunity of producing flexion, which, as experience has shown, tends to increase with use.

The operative procedures most frequently resorted to are: excision to obtain a false joint (pseudarthrosis); excision to obtain a better position of the limb; osteotomy, breaking the bone after partially cutting it with an osteotome; and osteoclasis, breaking the bone without any cutting. These different procedures have especial advantages in different joints, and can be fully studied and appreciated only under the headings of the individual joints.

H. Augustus Wilson.

ANNATTO (*Orleana*).—This coloring matter is obtained from the seed of *Bixa Orellana* L., a small tree of South America, belonging to the order *Bixaceæ*. The plant is also cultivated in all tropical countries. Commercial annatto is prepared in a variety of ways, having for their object the separation from the seed of its coloring matter, and its preservation in a moist or dry condition. The bruised seed is sometimes washed over a sieve and the liquid allowed to stand until the annatto subsides; or it is separated by fermentation. The product is a brownish-red, resinous substance, usually in moist masses, but sometimes in dry, brittle cakes. It has often little or no, sometimes a sweetish, resinous odor, and a saltish-bitter taste. Some lots have a very disagreeable smell, and are said by Hager to be prepared with urine. Two kinds are said to be imported from French Guiana, one without unpleasant smell, the other disagreeable. A third variety comes also from Brazil, but this is not so highly esteemed as the best French.

Annatto is a mixed susbtance, nearly insoluble in water, soluble in alcohol, ether, fatty and essential oils, making orange-red solutions. It consists principally of a yellow (*orellin*) and a red (*bixin*) resinous coloring matter.

The principal demand for annatto is for dyeing fabrics, but it is also extensively employed to color butter and cheese. In the tropics it is largely employed for coloring foods for table use. Internally given, it is said to be "tonic and antidysenteric."

W. P. Bolles.

ANODYNES.—This term (*a*, privative, and *ὀδύνη*, pain) is applied synonymously with *analgesics* (*a*, and *ἄλγησις*) to a small class of drugs whose peculiar action is to relieve pain. The anæsthetics, which also relieve pain, but by suspending all sensation, together with consciousness and motility, are not anodynes.

By far the most important member of this group is opium. (For detailed account of the action of this drug, see *Opium*.) Though other remedies occasionally relieve the milder degrees of pain, opium alone can be relied upon to remove severe suffering. It has its limitations, in occasional paroxysms of agony such as attend the passage of renal and gall stones, when nothing short of absolute anæsthesia will bring relief. Here opium, in doses so high as even to endanger the life of the individual, is without effect on the pain. In the ordinary forms of severe pain a failure of opium to give relief is almost always due to improper adjustment of the dose. Of course, the subsequent ill effects of opium, such as nausea, constipation, and narcotic addiction, may be so marked as to form a contraindication, more or less strong, to its use. But the point here emphasized is that, as an anodyne pure and simple, opium, if properly administered, is almost always successful. In certain subjects, particularly women and nervous persons, the intoxicating effect of opium predominates in the moderate doses. In such cases the dose must be cautiously increased beyond the limits usually prescribed, or else the opium must be combined with some nervous sedative, as bromide of potassium or chloral. For it should be remembered that opium is, in analgesic doses, by no means always a hypnotic. In many cases in which it completely removes pain, the patient does not close his eyes in sleep the whole night.

The common cause of failure in securing the analgesic effect of opium is conformity with a strict and arbitrary posological standard, and forgetfulness of the fact that there is much difference in the capacity of different individuals, and of the same individual at different times, for the drug. Under the influence of severe pain, the toleration for opium increases enormously. In general and pelvic peritoneal inflammations, for instance, it may be necessary, in order to get the full effect of opium, to administer it in doses up to four grains (or its equivalent in morphine) at a time, and to repeat with sufficient frequency to keep the patient just short of narcotism. This bold use of opium in pelvic inflammation has come into practice of late years, and some of the figures published of the amounts actually administered are very large. They are not given here, however, for the reason that no definite figures reported in one case should have any weight in determining the amount to be given in another case. It is needless to say that, in the case of a patient suffering from a frank peritonitis, which calls for the employment of these heroic doses, and when the individual is held just on the verge of narcotism, with respirations perhaps lowered to ten or twelve per minute, no standing order should be given in advance for a stated administration of the drug, and that each dose should be given by the practitioner himself, who should on no account leave the case, and who should have at hand atropine and a faradic battery ready for instant use in case the narcotism goes too far.

Among the derivatives of opium, morphine, as an anodyne, stands *facile princeps*. Its convulsant, constipative, and diaphoretic properties are all less than those of opium, while as an analgesic it is even more active than the drug from which it is derived. Of the other principal alkaloids, the analgesic effect upon man is in the following order: narceine, thebaïne, papaverine, and codeine. The interval between the strongest of these and morphine is, however, great, one authority claiming that narceine is four times weaker than morphine, and in practice it is found that none of them can be relied upon with certainty in pain of a severe character. The promptness and effectiveness of morphine as an anodyne are usually enhanced by the hypodermic method of administration.

Chloroform is at times an anodyne. This is especially the case when injected subcutaneously in the vicinity of a nerve, as in sciatica and other forms of neuralgia. Administered by the mouth it also has a local analgesic effect, due partly, no doubt, to its revulsive counter-irritant action. It is thus of use in gastralgia and flatulent colic. The spirit of chloroform, in doses of ʒ i. in hot water, is an eligible form for the internal administration of chloroform, and the Spiritus Ætheris Compositus, commonly called Hoffmann's anodyne, may be used in the same doses for abdominal pain. The so-called chlorodyne, a British nostrum, has under various modifications been pretty widely used. One of its many formulæ is this:

Morphinæ hydrochloratis	gr. viij.
Aquæ	fl ʒ ss.
Acidi hydrochlorici	fl ʒ ss.
Chloroformi	fl ʒ iss.
Tinct. cannabis indic	fl ʒ i.
Acidi hydrocyanici U. S. P	♏ xij.
Alcohol	fl ℥ ss.
Ol. menth pip	♏ ij.
Oleoresinæ capsici	♏ i.

The adult dose is from five to ten drops. This may be well replaced in the same dose by the Tinctura Chloroformi et Morphinæ, B. P., which was intended to be its official substitute.

Belladonna may be considered a feeble anodyne. Administered with opium it has not only a corrigent effect, mitigating some of the unpleasant symptoms of the latter drug, but is also apparently, to a certain extent, an adjuvant.

The various coal-tar products, whose name is now legion, have a certain anodyne value. Antipyrine, phenacetin, acetanilid, lactophenin, are a few among the many. (See also under *Antispasmodics.*)

Cannabis indica is a still weaker anodyne, if it deserves the name at all. Its hypnotic action can overcome a moderate degree of discomfort, but not much actual pain. It is of some repute in the treatment of chronic migraine.

There are, besides the foregoing, one or two drugs which deserve mention as local anodynes, although their commoner use is as local anæsthetics. For example, cocaine is chiefly employed to produce anæsthesia, as of the cornea, or by injection to anæsthetize the field for a circumscribed operation. Its anodyne action may be obtained, however, in conjunctivitis, in painful hemorrhoids, etc. A four-per-cent. solution may be employed. But the ever-present danger of establishing the cocaine habit must always be borne in mind before resorting to cocaine as an anodyne.

Cocaine itself is much less soluble in water than its salts, *e.g.*, the muriate; but the former is soluble in fats, while the latter are not. Hence in ointments the cocaine itself should be used, and not its salts.

Eucaine has been found in many respects a useful substitute for cocaine. *Charles F. Withington.*

ANONACEÆ.—(The Custard-Apple family.) A family of nearly fifty genera, pertaining almost wholly to the tropics, of both hemispheres. They yield a number of the most delicious of known fruits, such as those of *Anona* and *Duguetia*. They are classed near the Magnolias and Myristicas, and, like them, are rich, chiefly in the bark, in volatile oils, for which they are considerably used in domestic practice. *H. H. Rusby.*

ANOSMIA. See *Smell, Disorders of.*

ANTACIDS. See *Alkalies.*

ANTHELMINTICS.—Agents rendering harmless or killing worms. A *vermifuge* is an agent which expels worms, a *vermicide* one which kills them, but these terms are occasionally used as synonyms.

A priori any agent thus used must either be insoluble in the gastro-intestinal juices, and therefore non-absorbable, or else, if soluble, must possess the faculty of being innocuous to the host at the same time that it is destructive to the intruder. Drugs of this latter class are few, and the employment of nearly all absorbable drugs is distinctly hazardous, for their dose is necessarily large, and they not infrequently produce various phenomena of poisoning.

For convenience worms may be divided into three groups, each with its own treatment: tape worms or tæniæ; round worms; seat, pin, or thread worms.

Tape Worm or Tænia.—Drugs used in this condition are: pelletierine, and pomegranate from which it is derived, pumpkin seed, thymol, cusso, kamala, salicylic acid, silver oxide, chloroform, turpentine, and areca or betel nut.

In the treatment of tape worms the method of procedure is of as much importance as is the choice of the remedy to be employed. An absolute essential is the withholding of all food from the patient for from twelve to twenty-four hours. If this is impracticable the drug should be administered before breakfast, a light supper only having been partaken of the previous night. About three-quarters of an hour after the administration of the anthelmintic an active purge should be administered. For this purpose an ounce of compound tincture of jalap (French Codex) will be found useful, or a large dose of calomel may be used—and calomel has the advantage of causing a profuse outpouring of bile, which seems to be particularly obnoxious to these parasites. As the desideratum is the removal of the head or heads of the worm or worms, the stools should be carefully examined for their presence, and in any case a high rectal injection should be given, preferably of saline solution, as this is most useful in bringing away the head of the tænia, which may be narcotized but not dead. It is of the utmost importance that the bowel discharges be destroyed.

Of the agents used against this worm, three are largely and successfully employed, though at times two or even three drugs may have to be successively tried, and the treatment may even then fail. *Aspidium* is most useful in the form of the oleoresin, given in four capsules of fifteen minims each, at one dose, or in two doses half an hour apart. It is not to be forgotten that oils render soluble this agent, and never, therefore, should they be employed. Pelletierine may be used as the tannate, of which the dose is three grains, or else as the liquid alkaloid prepared by Tanret; the latter is very expensive and not always obtainable. *Pepo* is most effective and may be used by taking two ounces of the powdered pumpkin seeds to make an emulsion or a confection, this amount being the usual dose. *Thymol* has quite recently been advocated, and may conveniently be given in capsules of ten grains each, one capsule being taken every quarter of an hour until two drachms are taken. *Pomegranate* is used by taking two ounces of the bark, adding this to two pints of water which is boiled down to one pint, and of this a wineglassful is taken every half-hour. *Areca nut* is a comparatively new remedy, which depends upon a volatile oil and upon its active principle, arecaine, for its efficacy; it is employed in the dose of two drachms of the powdered nut. *Kamala* and *cusso* have the disadvantage of being required in large dosage, while they are most repugnant to the taste; the former is given in syrup, in the dose of two drachms, to which has been added some hyoscyamus to prevent griping, and the latter as the powdered flower, of which half an ounce is used to make a decoction with a pint of water. Of *koosin*, the active principle of cusso, twenty to forty grains may be given in capsule. The dose of *silver oxide* is one grain three times a day; it is of doubtful value. Salicylic acid, one-half drachm, combined with an equal amount of sodium biborate, added to a pint of water, has been recommended, but the taste of this solution is a serious drawback to its use. *Turpentine* and *chloroform* are certainly effective, but belong to the class of absorbable, and therefore dangerous, drugs. The dose of each is one drachm, and in their administration glutol capsules will be found of advantage.

Children under two years of age react badly to tæniacides as a rule, and great care must be taken in treating them for this condition.

Round Worm or Ascaris Lumbricoides.—These worms affect children rather more than adults, and infest the upper part of the small intestine, though rarely they work their way up into the stomach, and even into the œsophagus and pharynx. Drugs used against this parasite are: santonin (the glucoside of santonica or levant wormseed); spigelia or pink root; chenopodium or American wormseed; turpentine; azedarach or pride of China; mucuna; tin. Probably the best of these is santonin, which can be conveniently administered, as it is tasteless, in powders of two grains, alone or combined with calomel. Equally useful is spigelia in the form of the fluid extract, of which the dose is two drachms, or, better, the fluid extract of senna and spigelia (unofficial) may be used in a dose of half an ounce, the senna in this case acting as a purge. Oil of chenopodium, in the dose of from twenty to thirty minims, which may be dropped on sugar, is very useful; turpentine, half an ounce, combined with castor oil, one ounce, is generally most efficient, but should not be used because poisonous effects, particularly renal inflammation, may occur from its absorption.

Azedarach has the disadvantage of requiring a large dose, two ounces of the drug being added to a pint and a half of water, which is then made into a decoction by boiling the mixture down to one pint; it is nevertheless most useful. Mucuna and tin are barbaric relics, their administration being as crude as their preparation and mode of action. They belong to the class of so-called mechanical anthelmintics. Mucuna, a West Indian plant, was used by scraping the pods of the plant of the hairs or spicules which cover them and adding to this molasses or syrup. The patient swallowed this mixture, and the spicules in their passage down the intestines were supposed to transfix the worm. The tincture and decoction have no virtue, and mucuna, so largely employed at one time, has passed away.

In treating any patient for the presence of ascarides, it is necessary, as in the case of tænia, that food be abstained from for twelve or, better, twenty-four hours; that an active purge be administered about three-quarters of an hour after the remedy has been taken; and that the bowel discharges be destroyed.

Seat, Pin, or Thread Worms: Oxyuris Vermicularis.—These worms generally infest the rectum and colon, and are most common in children. The following drugs are those usually employed, but anthelmintics used against the tape and round worm can be used, as many of them are equally destructive to the seat worm: quassia; saline solution; carbolic acid; lime water; iron; tannic acid and drugs containing large amounts of tannic acid, such as catechu, kino, and krameria.

Quassia is unquestionably the most efficient of this list, and has at the same time the advantage of being non-irritant and non-poisonous. A rectal injection, consisting of one ounce of the fluid extract added to a pint of water, or of a decoction made of an ounce of quassia chips added to a pint of water, is given. Before using this or any other injection the bowel should be thoroughly cleansed with soap and water, and it is imperative that the injection be retained, by pressure over the anus, for fifteen or twenty minutes, and that the region around the anus be thoroughly washed with salt and water. Failure to observe these precautions will render the treatment of little avail. Of the remaining drugs, saline solution is probably the best; carbolic acid (one-per-cent. solution) has its advocates, and is often used immediately after the quassia injection; it should not be employed, I believe, for two reasons: first, because it may cause sloughing, and, secondly, because dangerous symptoms may follow its absorption from the rectum. Alum (one ounce to a pint of water), lime water, iron, and tannic acid act as astringents.

For cleansing with soap and water and for injecting the medicament a soft rubber catheter or rectal tube will be found most useful in aiding the solution to go well up into the colon, and it is advisable to repeat the treatment two or three times at intervals of a day or so.

Charles Adams Holder.

ANTHRAROBIN.—Dioxyanthrol, desoxy-alizarin, leuko-alizarin, $C_6H_4,COH,CH,C_6H_2(OH)_2$. This is prepared by the reduction of commercial alizarin in warm ammoniacal solution with zinc dust, and subsequent filtering into water acidulated with hydrochloric acid. The resulting precipitate is washed and dried.

Anthrarobin is a yellowish-white, granular powder, insoluble in water and dilute acids, slowly soluble in chloroform and ether, and freely soluble in glycerin and in ten parts of alcohol. In aqueous solutions of alkalies or alkaline earths it dissolves with a brownish-yellow color, which, through oxidation and the reformation of alizarin, rapidly turns to green and then blue. Claimed to have the same virtues as chrysarobin, this substance has the advantages of being non-irritating, and of causing but slight staining of the skin. Clinical reports differ as to its efficacy; for example, Jackson says that it is a weak preparation and not of much value, while Behrend and others consider it superior to chrysarobin. These latter use it as a parasiticide and stimulant to the skin, and especially commend its use in psoriasis, pityriasis, tinea tonsurans, tricophyton, and herpes. It is employed in ten- to twenty-per-cent. ointment, or in solution in glycerin or alcohol, or in collodion. It must not be applied in the immediate neighborhood of the eye, as it has a tendency to spread. A prescription that is recommended contains anthrarobin and salicylic acid, of each one drachm, in alcohol sufficient to make one ounce. Behrend's mixture consists of anthrarobin 10 parts, borax 8 parts, in water 82 parts, or he uses a ten-per-cent. solution in glycerin.

W. A. Bastedo.

ANTHRAX.*—(Synonyms: Carbunculosis Contagiosus; Milzbrand; Charbon; Wool-Sorter's Disease; Mal de Rate; Mycosis Intestinalis; Anthracæmia; Malignant Pustule; Splenic Fever.) (See also *Carbuncle* and *Furuncle.*)

A specific, highly infectious disease, common to most vertebrate animals and communicable to man (though in varying degree). The disease is not contagious in the ordinary sense of the word, but it is in a high degree communicable by means of secondary media of infection. It maintains its virulence for long periods, and suffers no deterioration from transportation or variations of climate or other external conditions. It appears as an acute intoxication, usually of a restricted part of the body, but later of the entire body, and is due to the invasion of the tissues of its host by the bacillus anthracis. The disease is primary in animals, and occurs in the human subject in two distinct forms, viz., by direct inoculation, or indirectly by eating the flesh of animals infected with anthrax or by inhaling dust which is contaminated with the poison of anthrax, as in the operations of currying hides, upholstery, mattress-making, etc. The blood, tissues, and excretions of an animal dead from anthrax are found to contain a minute organism, in the form of a rod bacillus, which has been demonstrated to be the specific and invariable cause of the disease, and may be obtained in every fully developed case of anthrax. At the point of invasion the bacillus first acts as a purely local poison, producing only a local irritation, but it soon multiplies rapidly, and later is conveyed by the circulating blood into all parts of the body, where by its enormous numbers it blocks the capillaries with embolic masses of bacilli, causing innumerable hemorrhages into the organs and tissues, and effusions into the serous cavities and cellular structures; and by its specific toxin acting upon the sympathetic nerve centres it produces great depression of the vital functions, which often ends in death within a few days.

Anthrax is the most widely spread and the most destructive of all communicable diseases which affect animals. The malady is primary in the herbivora, and is found in all countries. It is very prevalent in parts of France, Germany, Italy, Persia, North and South Africa, and South America. It is least prevalent, though not absent, in Australia, North America, and the British Isles. Epidemics of the disease often appear among cattle and sheep of affected regions, and may be fatal at the rate of from fifty to seventy per cent. of the animals attacked. It also attacks human beings in infected districts by inoculation from the lower animals, and is often attended with great fatality. All classes of vertebrate mammals are susceptible to anthrax. The disease does not spread by contact or association; it can be acquired only by the introduction of the infective organisms into the body, either through an abrasion of the skin or a defect in the mucous membranes, or by the spores of the bacilli finding their way through the epithelial lining of the alimentary canal or respiratory tract, and so causing general infection. The inoculation of these organisms produces the same fatal effect upon animals as does the infection from the original source of the primary disease. Blood taken from a diseased animal is also fatal if introduced into the tissues of another susceptible healthy animal; but if the

* The bacteriology of anthrax will be considered in the article entitled, *Bacteria, Pathogenic*. For this reason no allusion has been made to the subject in this article.

blood is filtered previous to its introduction, so as to remove all germs, it is no longer infectious to a healthy animal (Klebs, Pasteur).

Anthrax cannot under any circumstances originate *de novo*, but is always communicated by some medium capable of conveying the infection; and it is always transmitted directly or indirectly from pre-existing cases, or by the products of such cases, from animals dead of the same disease.

In Great Britain, anthrax is included among the maladies specified under "The Contagious Diseases Acts." In England, numerous outbreaks of anthrax have been traced to the refuse of washings from wool, hair, etc., which are discharged into streams or sewers, and from the solid residue which is used for manure.

Twelve men and sixty head of cattle died of anthrax in Pennsylvania during the year 1897. The men were, without exception, operatives in local tanneries, and the cattle were from pastures watered by the stream carrying off the refuse of these tanneries (*Modern Medical Science*, vol. xii., No. 7, January, 1900). Ten cases of anthrax were admitted to the Liverpool Northern Hospital between March 13 and July 8, 1893. The source of the disease was found in two tanyards which had become infected from some hides imported from China. The diagnosis was not doubtful in any of the patients, and was supported by microscopic examination in all the cases, in six of which it afforded absolute proof of the nature of the disease. Later, three additional cases were admitted to the same hospital, of whom two were workmen from the same tannery. The third was a woman employed as a wool-sorter. Three other cases were reported from the same establishment which were treated elsewhere. The mortality is reported at forty-four per cent. (*The Lancet*, January 20, 1900, p. 164.)

Animals rarely take the disease from other animals, but obtain it indirectly from the soil or other secondary medium of infection. Thus, certain restricted regions or localities become centres of infection where the disease shows itself year after year. This may arise from the superficial burial of animals dead from anthrax, which leads to the infection of the soil, which, once produced, is not easily eradicated. In portions of the province of Brandenburg, the owners of cattle have learned by oft repeated experience the exact boundaries of limited districts, and even of certain fields, where anthrax contamination persists in the soil. The same condition prevails in certain portions of the Bavarian Alps.

No ordinary changes of temperature, such as freezing of the ground, affects the vitality of the organism. Stable implements, veterinary surgical instruments, etc., may spread the disease among healthy animals. The bodies of animals when buried are not so dangerous for the propagation of anthrax as are the blood, intestinal contents, etc., which may be scattered on the surface of the ground or adhere to grass, shrubs, etc.

Herbivorous animals, such as cattle and sheep, are more susceptible to the intestinal form of anthrax, but are less often affected by the external form of the disease, the so-called "malignant pustule." Others, such as guinea-pigs and rabbits and white mice, are less often attacked by the intestinal forms, but are more susceptible to subcutaneous inoculation by experiment. The carnivora are less susceptible than other classes. Animals ordinarily acquire anthrax by way of the intestinal canal, through infected fodder, stable litter, manure, or from water polluted by anthrax infection; or from infection of the pastures or fields owing to the exposed bodies of animals dead from the disease; or from the contamination of the grass by the anthrax germs from the dead body of an animal which has been buried in the vicinity.

Direct inoculation of anthrax in man is not very common. It can happen only in those whose calling brings them in direct or personal contact with the diseased or dead animal. There must be also either an abrasion of the epidermis or a wound of the skin to insure infection. Veterinaries and knackers have been more frequently affected than physicians, nurses, undertakers, or butchers. There is danger to man from flies about those affected with anthrax, as it has been proved that the virus of many infectious diseases may be conveyed by insects, either from soiling of their bodies or limbs with the infectious material, or from their dejections which may contain the germs of an infectious disease.

Anthrax in man, in this country at least, is almost exclusively limited to those working in animal products imported from other countries where the disease exists. The dead animal is far more dangerous when thus distributed than is the living animal to the human beings in its own immediate vicinity. Infection may occur through the skin, intestines, or the lungs. In a guinea-pig a single bacillus of virulent anthrax is capable of producing fatal infection. Experiments on rabbits have shown that general as well as local infection may follow the rubbing of certain pathogenic bacteria into the uninjured skin. In infected localities the anthrax bacillus lives in the soil, and may thus render certain portions of a field or pasture where the bodies of animals dead from the disease have been buried a permanent source of the disease to other susceptible animals through long periods.

The greatest source of danger in this disease lies in the fact that the virus may be introduced through the smallest abrasion or injury of the skin, or of the mucous membrane of the alimentary canal. The degree of susceptibility of different animals to the poison of anthrax is not uniform. The herbivora are especially susceptible (experimentally, rabbits and guinea-pigs), the omnivora are less liable to take the disease (pigs, men, etc.), and the carnivora are least susceptible to the virus. Strong, healthy animals are more easily affected than the lean or sickly. One attack affords no protection against a recurrence of the disease. To show the ravages of this disease, it may be stated that in Russia, in the year 1864, no less than 72,000 horses were destroyed by it. In the province of Novgorod, within four years, more than 56,000 horses, cows, and sheep, as well as 525 men, fell victims to this terrible scourge (see Bollinger). The disease spreads among men in proportion as they are exposed to infection from diseased animals or men. Shepherds, farmers, butchers, coachmen, stablemen, as well as veterinary surgeons and those individuals who handle animal products, such as wool-sorters, curriers, mattress-makers, etc., are especially exposed. Horsehair is particularly dangerous. Further, articles like hides, horns, wool, etc., from countries where the disease is prevalent, which may be transported great distances, are liable to convey the infection and thus give rise to the malady among those employed in their transportation or manufacture. Trousseau mentions two factories in Paris, in which horsehair from Buenos Ayres was used in upholstering furniture, and in which not more than six or eight workmen were employed: during ten years twenty laborers died in these establishments from anthrax. Even after the hair has been long in use, the disease may be induced in the form of true malignant pustule in those employed in renovating the upholstering. A small scratch or crack in the skin or mucous membrane is sufficient for inoculation, and frequently the disease is introduced into the system by the unclean nails or fingers of workmen in scratching the face or arms. The disease may be spread from man to man. The discharge from the pustule (anthrax carbuncle) contains the bacilli of the disease, and its inoculation will be followed by the development of anthrax. Repeated transmissions of virus do not cause a diminution of virulence: the last generation is as highly infectious as the first. Anthrax is observed in men in the proportion of fifty-nine per cent., to forty-one per cent. in women. The seat of the primary sore, the malignant pustule, was found by Virchow to be confined to the face, hands, fingers, forearm, or neck in eighty four per cent. of cases. In the rest, sixteen per cent., the arms and lower extremities were the seat of infection, and in these cases the patients were chiefly women and children, in whom these regions are more exposed than in men.

There is a varying susceptibility to anthrax among

different families of the same race. This has been observed in both men and animals. Thus the negro is less susceptible than the white man, and certain breeds of sheep, notably the Algerian variety, are less susceptible than other breeds. Deer, reindeer, and elephants are also liable to the disease.

The bacillus of anthrax is famous as being the first micro-organism to be discovered as the actual cause of an infective disease. In San Domingo in 1770 it was the cause of the death of fifteen thousand persons in the space of six weeks from eating the flesh of animals dead from the disease.

All forms of anthrax are caused by a single organism. It is at first a local lesion which may be destroyed by thorough excision or by efficient caustic treatment. The disease is not necessarily always fatal. Dr. Budd, of Bradford, England, had nine cases, of which eight resulted fatally.

Other observers in mostly tropical countries report as low as twelve per cent., or even five per cent., mortality. Such a statement should, however, be taken with some amount of reservation. In forty-eight cases of external anthrax treated at Guy's Hospital in London, thirty-nine recovered after operation for the destruction of the local disease. The infection of a wound of entrance of the poison cannot be prevented by the immediate irrigation of the wound by corrosive sublimate or carbolic acid when the bacilli have once gained entrance into the flesh.

There is always a local lesion in some part of the body by which the virus of anthrax gains entrance to the system. The disease is by no means always fatal to animals. Fagge states the average mortality among horses and horned cattle to be seventy per cent. The disease is accompanied in cattle with enlargement of the spleen as a very characteristic condition. Many cases show no external lesion, as the infection may be taken by the mouth in swallowing, or may have been inhaled. There are then rarely premonitory symptoms; the patient is seized with a chill, becomes faint and prostrated, has pains in the back and legs, the temperature rises to 102° or 103° F., the breathing is rapid and there is much pain in the chest, the pulse is feeble and very rapid, and there may be vomiting. From the prominence of these symptoms the pulmonary form of the disease has at times been diagnosed. Death may occur in twenty four hours. Cerebral symptoms may be very marked in the course of the disease.

When the disease is located in the chest, there is great resemblance to a rapidly spreading pneumonia with subsequent heart failure. It is probable that many cases of "pneumonia" occurring in manufactories of carpets, blankets, furs, etc., are really thoracic anthrax. The recognition of "wool-sorter's disease" as a form of anthrax is due to Dr. J. H. Bell, of Bradford, England. Eppinger has shown "rag-picker's disease" to be a local anthrax of the lungs, with subsequent general infection of the system from this source.

The term "maligant pustule" is inappropriate and misleading, as the disease is often not malignant, and the pustule never contains pus.

Course of the Disease.—*External Anthrax.*—During the first day the seat of infection is more or less irritable, sometimes painful. The continued itching of the part, with augmentation of the redness, an œdematous swelling, together with shooting pains in the locality, with red lines beneath the skin, marking the course of the swollen lymphatics, are among the strongest initial symptoms of anthrax. As the disease progresses, these conditions increase in intensity, and the tissues about the point of infection become discolored and variegated in tint. The formation of a vesicle at the point of infection, with subsequent rupture, and the appearance of a crust or scab are decidedly characteristic. Fever is often present even at this stage, though it may not be observable in the early stages. Diarrhœa is frequent. Malignant cases may terminate fatally in from twenty-four to forty-eight hours, and are often preceded by collapse.

During the second day there usually appears a vesicle varying in size from 1 to 3 cm., with a yellowish or brownish exudation. At about the third day, the vesicle bursts and shrinks, leaving a brownish base, exuding serum. On the fourth day there is a black, dry, depressed crust or scab, often called the eschar, which is surrounded with a very characteristic, slightly elevated border or wreath of small new vesicles. There may be other discrete or confluent vesicles in the neighborhood. Pus is first observed at the end of the tenth or fifteenth day, if the patient lives so long, when the separation of the sloughing eschar, accompanied with suppuration, occurs in the usual manner.

The initial symptoms of anthrax are similar to those of other acute febrile diseases: weakness, malaise, chilliness or moderate rigor, headache, thirst, restlessness with or without mild delirium, sometimes vomiting and disturbed sleep. The subsequent symptoms vary in character and intensity according to the external localization of the disease. If this is in the stomach, there may be obstinate vomiting; if in the intestine, persistent diarrhœa; if in the pulmonary structures, rapid breathing, with symptoms similar to those of extensive pneumonia, cyanosis, and speedy collapse. Serious disturbance of the brain may be associated with any of these conditions, accompanied with convulsions and coma. The temperature curve is similar to that in other acutely toxic febrile conditions, ranging from 102° to 105° F.

Dr. Hamer reported a mortality of forty per cent. in cases of anthrax of the neck, while the mortality in cases in which the primary lesion was situated upon other parts of the body was twelve per cent.

Anthrax is less fatal in tropical countries, where the condition of the climate, heat, sunshine, etc., may produce diminished virulency of the specific organism of the disease. Perhaps a greater resistance to the effect of the bacilli, or of their toxins, on the part of the inhabitants, or a greater toleration of the infective poison, may account for the less fatal character of the malady in those regions where the mortality has been *reported* as extremely low, varying from zero to one per cent.

A pronounced systemic reaction with much local inflammation has been thought favorable to recovery. In asthenic conditions of the system the prognosis is less hopeful. The pulse, respiration, and temperature are not always indicative of the gravity of the disease or of the probable result.

Dr. Bell gives the following table of mortality in relation to the duration of the disease:

Days	2d	3d	4th	5th	6th	7th	8th	9th
Cases	2	3	12	6	11	10	5	5

Over nine days, 1 case; total, 55 cases.

Intestinal Anthrax (*Mycosis Intestinalis*).—In some cases the primary lesion of anthrax, the malignant pustule, is seated upon the internal surface of the bowel, and produces the symptoms known as those of mycosis intestinalis, followed by the same train of fatal results as when the primary lesion is upon the external surface. Often the milk and the flesh of diseased animals are taken as food, and doubtless the infection frequently occurs from this source. The course and symptoms of this form of the disease are not well understood. Often the workmen engaged in slaughtering diseased animals become infected by direct inoculation, while those eating the flesh of the same animals experience no harm. It is probable that the bacilli are destroyed by the processes of cooking, which generally require an elevation of temperature sufficient for their sterilization; or possibly they may be rendered harmless by the gastric digestion; but if they succeed in passing the stomach, they may then become seated in the mucous membrane of the bowel and there produce the disease.

Intestinal anthrax is rare in man, though it has been occasionally reported. (For a most interesting case see

"Medical and Surgical Reports," Boston City Hospital, 1896–99, p. 226.) The distinction between the intestinal and pulmonary forms of anthrax is not easily made, and doubtless the two may often be confounded with other acute diseases affecting these organs, unless the anthrax bacillus is identified by microscopical examination, or the disease be reproduced by inoculation in animals. The diagnosis of intestinal anthrax may be quite impossible, owing to the rapidity of its progress and the similarity of its symptoms to those of other gastro-intestinal diseases, especially to those of ptomaïne poisoning. The course of intestinal anthrax is almost uniformly fatal, and Bell states that no case demonstrated during life to be intestinal anthrax has recovered.

Treatment of this variety of the disease should consist of rapidly acting evacuants, followed by the administration of internal antiseptics (germicides), with supporting measures according to the conditions present; but the nature of the lesion and the rapid progress of the disease would preclude the hope of benefit from any available means of internal medication.

Pulmonary Anthrax, Wool-Sorter's Disease, Anthracæmia.—This form of the disease may be acquired by inhalation of the dust from any of the products of diseased animals. Thus it has been observed among those employed in the handling or manufacture of animal hairs and woollen rags; among wool sorters, rag pickers, and those concerned in the further manipulations of these articles into woven textures; and to some extent among paper-makers. Dr. Bell says: "The sorting of wools and hairs is unhealthy in proportion to the contamination they produce in the air inspired by the workmen. First, the dust and fine short hairs, acting mechanically, excite chronic diseases of the lungs, such as bronchitis and phthisis. Second, dust from dried and decomposing animal matter produces a low form of septic pneumonia. Third, the virus arising from the blood and discharges of animals that have died from anthrax acts specifically on the lungs."

Pulmonary anthrax is peculiarly a human complication. It is not often observed as a coincident condition in either cutaneous or intestinal infection. "From the paramount dignity, in the human economy, of the organ invaded, and the specific tendency in anthrax to the development of œdematous conditions in the tissues invaded, it is not surprising that pulmonary invasion leads to a most acute and generally fatal manifestation of anthrax, recovery occurring but seldom." *

The general duration of the pulmonary invasion before the fatal termination is from two to five days. The bacilli are often present in the sputum.

PATHOLOGY.—The pathology of malignant pustule consists of the series of changes which follow inoculation with anthrax through either the skin, the alimentary canal, or the lungs. These changes are somewhat different, according to the particular circumstances of the individual case. When the virus is introduced through a scratch or abrasion of the skin, the period of incubation, or the space of time before the local symptoms of anthrax appear, may vary from a few hours to three days; in rare cases a somewhat longer time may elapse.

The course of the disease may be divided into three stages. The first or prodromal stage is that of incubation (period of latency). During this period the patient presents no marked symptoms of any serious disturbance. There are localized burning and itching at the seat of infection, which are generally thought to be due to the bite of an insect, such as a flea, which the spot closely resembles. After a period of incubation lasting from a few hours to three days (rarely longer) the local symptoms suddenly change. The second stage, that of eruption, now ensues, in which a small papule is seen at the seat of the previous irritation. This rapidly increases in height and in circumference, and generally presents a spot of dark discoloration at its summit. The itching and burning increase, and within a few hours a vesicle appears at the seat of discoloration in the papule. The vesicle now rests upon an indurated base, and contains a small amount of a serous, frequently bloody fluid. The surrounding skin swells so as to form a slight elevation around the vesicle, which now exhibits the peculiar appearances to which it owes its name of "malignant pustule," although this is not an accurate definition of the pathological condition at the seat of the local disease. The vesicle soon ruptures spontaneously, or is ruptured by the scratching of the patient, and reveals a dark red base, which quickly dries, forming a livid or brownish crust. This is the commencement of the central gangrene or necrosis of tissue commonly observed in the carbuncle of anthrax. The crust becomes gradually larger, until it sometimes reaches a diameter of from 1 to 3 cm., and the swelling and tension of the surrounding skin become more extensive. A line of new-formed vesicles becomes developed around the margin of the crust, and these vesicles contain a yellowish or brown fluid content.

The crust now gradually becomes free from pain and tenderness, and a doughy or boggy infiltration is felt for some distance in the tissues around the primary sore. The local condition, however, has no diagnostic value as an indication of the infection of the general system. In rare instances the local symptoms become less serious, the swelling subsides, the slough separates and is thrown off, and the ulcer heals by granulation. In such cases the chief danger is from septicæmia arising from the absorption of gangrenous matter. When general infection occurs the swelling increases and becomes doughy, the lymph channels are detected as reddened lines of induration, the glands become swollen, and burning heat is felt in the part, which gradually becomes very painful and later is the seat of a feeling of stiffness and numbness. The veins are often seen as dark-colored channels, and are sometimes plugged by thrombosis.

The foregoing appearances are caused by the local multiplication of the bacilli of anthrax in the part which is the seat of the primary infection. On the second or third day the germs may be found in the central part of the carbuncle and in scattered groups in the rete Malpighii. At times large interwoven masses of germs are found in the tissues at this early period, and may be observed to spread into the neighboring parts by extension beneath the epidermis. In a carbuncle extirpated by Bardeleben on the twelfth day, which measured 5 cm. in diameter, the bacilli were present in such enormous numbers that the tissues were everywhere crowded with them; they even filled the spaces between neighboring cells and obscured the normal structures of the part. In a carbuncle examined by Wagner the bacilli were so abundant as to hide the normal tissues. The centre of the pustule is generally the seat of hemorrhage, and the effused blood is prone to undergo putrefactive changes. This accident is also frequently observed in the œdematous tissue immediately surrounding the pustule. From this centre of the disease general infection of the body (third stage) may now quickly take place, some cases requiring but a few hours (*cas foudroyants*), while others occupy from three to four, sometimes eight to ten, days for general poisoning of the system.

A second form of the disease is the "œdema carbunculosum seu malignum," "Milzbrandœdem." This is observed in cases in which inoculation occurs in parts covered with thin delicate skin, such as the eyelids, axilla, and occasionally the extremities. In these cases the local sore, the pustule, is not formed, there is no crust, no central gangrene, nor an eruption of vesicles, but a rosy, bluish, or even livid swelling appears at the seat of primary infection, and rapidly spreads in all directions. Generally the spot where the inoculation occurred may be seen as a dark point more or less elevated above the surface, but sometimes there is no visible point of origin. The swelling is frequently enormous, so that the arm may be three or four times its normal size, or the eyes may be entirely closed by large effusions of translucent

* Billings in "Twentieth Century Practice of Medicine."

fluid in the tissues. Like the previously described local manifestations of anthrax, this malignant œdema may subside spontaneously without causing destruction of the tissues, and the part may be restored to its former condition. There is generally abundant desquamation of epidermis after the disappearance of the œdema. At times the swelling is so enormous that the skin becomes gangrenous to a greater or less extent, and often the œdematous area is the seat of vesicles or blebs which are filled with a bloody serum, and at the base of which is generally found a slough comprising the entire thickness of the skin. When the neck or eyelids are the seat of extensive œdema and sloughing, the loss of tissue may be so great as to lay bare the great vessels or other important structures, and death may ensue from hemorrhage or from some other accident not belonging to the course of anthrax.

General infection may occur when the primary lesion is seated in the intestinal tract, as well as when the inoculation has taken place on the external surface, and the character of the disease is not essentially different. The primary affection has received the name of "anthrax intestinalis seu abdominalis," or "mycosis intestinalis," and is described by Buhl, Waldeyer, E. Wagner, and others. These cases generally run a most alarming, pernicious (*foudroyant*) course, and it is chiefly by examination of the intestine that the identity of the disease has been established. This form of anthrax is generally induced by eating the uncooked or insufficiently cooked flesh of infected animals (*e.g.*, sausages, sandwiches of raw meat, etc.).

General infection of the system corresponds to that period in the development and multiplication of the bacilli in which they have penetrated beyond the seat of primary infection, have reached, by means of the blood channels or other paths, the internal organs, and have commenced to multiply in these structures. The bacilli are probably carried by the blood corpuscles, which often contain them in considerable numbers. The disease progresses much more rapidly in the intestinal form, probably from the sudden liberation of larger numbers of bacilli, which enter the circulation from many points at once.

The *anatomical appearances* in anthrax are those dependent upon a multiplication of the bacillary organisms in the body, and there is hardly a structure or a tissue in the dead body in which they may not be found in great abundance. They form thrombi in the capillaries, the lymphatic channels and glands; the brain, kidneys, and intestinal glands are found more or less crowded with them. The most striking changes are hemorrhages in the tissues, varying in amount from mere points to large extravasations. Œdematous exudations and serous effusions in the various cavities, and serous infiltration in various organs, frequently ensue. The visceral organs are generally found in a normal condition, with the exception of the spleen, which is usually enlarged and softened in structure, and contains enormous collections of bacilli. There is a marked increase in the number of white corpuscles, and death is quickly followed by strongly developed rigor mortis.

In general appearances the clinical picture of fatal anthrax closely resembles that of virulent blood-poisoning. As a rule, cases of malignant pustule terminate fatally in from three to seven days, though in cases of special virulency death may occur within a few hours.

The GENERAL SYMPTOMS of anthrax are usually the following: Chilliness, or a well-marked rigor, faintness, pains in the limbs, loss of appetite, sometimes severe distress in the region of the stomach, colic, meteorism, vomiting, and diarrhœa, frequently accompanied by bloody stools. There is excessive thirst. The patient retains consciousness to the end, unless coma should supervene shortly before death. Frequently there is great agony and distressing anxiety; the patient begs for relief in the most piteous manner, and feels that dissolution must soon ensue. In other cases there is stupor from the first, or the patient becomes delirious, or sinks into a deep coma, or the body may be convulsed by clonic cramps or continuous trismus or tetanic contractions. Occasionally there are harassing cough and dyspnœa, with bloody expectoration. There may be frequent hemorrhages in the tissues or from the mucous membranes, and sometimes secondary pustules are formed which are similar in all general characters to the primary lesion. Usually there is considerable elevation of the body temperature at the period of invasion of anthrax, the thermometer often registering 40° C. (104° F.), or higher, for some days, when there is a sudden fall to a temperature at or below normal, frequently as low as 36° C. (97° F.). The pulse is generally accelerated, and increases in frequency until death. The action of the heart is often feeble, and the sounds are hardly audible. Death usually occurs from collapse and general cyanosis.

Cases of intestinal anthrax are generally more virulent than the ordinary ones of malignant pustule, and they result fatally sooner than those in which the infection takes place from the external surface. The effects seem to depend upon the mechanical action of enormous masses of germs within the body, and upon the destruction of large portions of tissue by the growth and multiplication of the bacilli, together with the added action of the specific toxin produced by these organisms, which may be supposed to be more rapidly disseminated from this origin than when the initial lesion is situated upon the cutaneous surface.*

The progress of anthrax when acquired by inhalation is variable, but usually the course of the disease is rapid, and tends toward a fatal termination. The symptoms are often unimportant or insignificant until near the end. In some cases the invasion of anthrax is followed by sudden collapse with speedy death of the patient, as from shock; but generally there is more or less reaction, followed by collapse and death, without the signs of any inflammatory lesion in the lungs. When the patient survives a sufficient time for inflammatory processes to develop in the lungs, the risk from the anthrax poison is reduced. The duration of pulmonary anthrax varies from one to ten days. A large proportion succumb to the disease within the first four days.

The bacilli may or may not be found in the blood, but if the disease is really anthrax, the subcutaneous injection of the blood in a mouse will certainly prove fatal.

The specific action of the bacillus upon the body of its host, aside from its presence in enormous numbers, has been sought in the morphological character of the organism; the germ belongs to the aërobic class of organisms, and is a greedy consumer of oxygen; and it has been thought that the great prostration of the system, and the signs of the destructive action of the disease, as well as its rapid progress, may be due to the fact that it depletes the red blood cells of their supply of oxygen, and thus induces a sudden collapse of the vital powers. This view is supported by the appearances presented by the disease in grave cases, in which there is cyanosis to a marked degree, and the patient dies with all the appearances of asphyxia. In this respect the organism of anthrax produces in the animal system an effect similar to that of certain poisons of the cyanide group, in which death is uniformly associated with asphyxia.

In cases in which the disease progresses slowly, the secondary toxins formed by the bacilli are probably the cause of the fever and other constitutional disturbances.†

The dissemination of the bacilli through the system is chiefly by way of the lymphatic channels and the glands. Only after passing these physiological barriers can they obtain entrance into the general circulation and pass to all parts of the body. Therefore they would not be detected by microscopical examination of the blood, as an

* See a very interesting account of "Charbon" by Larrey in his "Memoirs," vol. i., p. 59, an abstract of which, by Mr. H. G. Howse, appears in The Lancet, December 23, 1899, p. 1720.

† "We may further take it as certain that micro-organisms cause disease almost entirely by virtue of certain toxic substances which they produce."—Prof. J. A. Lindsay, Lecture at Queens College, Belfast, November 20, 1899; Lancet, December 30, 1899, p. 1799.

aid to diagnosis, until a period when the condition of the patient is beyond relief.

After entrance into the general circulation, the organisms of the disease invade every tissue and organ in enormous numbers. Bacterial embolism is common; the heart muscle is invariably swollen and anæmic, and at times the seat of petechial hemorrhages. The same appearance with more or less ecchymosis may be observed beneath the endocardium, pleura, and pericardium, as well as in the substance of the lungs. The same condition may also exist in respect to the vessels and serous membranes around and within the brain.

DIAGNOSIS.—The diagnosis of anthrax is often very far from easy. Dr. Bell says: "The slightest illness occurring in those exposed to infection from anthrax should be looked upon with suspicion until the possibility of its being anthrax has been negatived. Often it is impossible to make an early diagnosis, as the symptoms may resemble those of ordinary illness. The progress of the disease is frequently not characterized by alarming indications until near the end of life, hence not infrequently it is unrecognized until the patient is cold, livid, almost pulseless, and dying."

The occupation of the patient may afford a valuable clew, or at least awaken a suspicion of the disease in a given case. Under such circumstances, a papule upon any exposed surface of the body would excite a suspicion of the disease, though a positive diagnosis might at this time be impossible. When the disease has advanced to the vesicular stage with serous exudation, there would be less uncertainty as to its nature. Implication of the lymphatic channels and swelling and tenderness of the neighboring glands would add weight to the probable diagnosis, though all these symptoms may be associated with other infectious diseases. The most certain method is that of taking a drop from the contents of the pustule or vesicle, and subjecting it to microscopic examination. If the case is one of anthrax, this fluid will be seen to contain the bacillus. This at once establishes the character of the disease in distinction from simple nonspecific carbuncle and furuncle. In doubtful cases the liquid may be subjected to cultivation in a moist chamber, when a definite result may be obtained within a few hours. Or the experimental inoculation of guinea-pigs and rabbits or other animals susceptible to the disease may be carried out; and if anthrax develops in them, there will then be no doubt in regard to the nature of the disease; but a negative result does not entirely exclude malignant pustule.

In districts in which malignant pustule is known to prevail, the surgeon would suspect this disease in the early stages of simple carbuncle, or of furuncle, and in the stings of wasps and other insects. Malignant pustule also resembles the early stages of erysipelas to some extent. Boils or furuncles are frequently very similar in their early stages to the first appearances of anthrax. In certain tissues they also often commence by the development of a vesicle at the seat of irritation. In furuncle, however, there is not so extensive inflammation in the vicinity, and the central gangrene, the crust, the wreath of vesicles, and the febrile action are absent; these symptoms belong exclusively to anthrax. The ordinary simple carbuncle is very painful, the carbuncle of anthrax, on the contrary, is only slightly sensitive. Bites of insects generally show a small yellowish point, which is not observed in anthrax. Erysipelas, especially when accompanied by serous effusions (bullæ), resembles the malignant œdema of anthrax to some extent, but in erysipelas the chill and fever usually precede the eruption of the disease, while in anthrax these occur simultaneously.

In glanders the carbuncles are smaller, generally multiple, and accompanied by intense febrile reaction.

Cases of intestinal anthrax, mycosis intestinalis, may be very difficult of diagnosis. The symptoms often resemble those of poisoning by arsenic or phosphorus, though the appearances due to anthrax are frequently more suddenly developed and advance more rapidly to a fatal termination than in cases of poisoning by these substances. Often the patient is dead within a very few hours.

PROGNOSIS.—The prognosis in anthrax is always very grave, and statistics prove that more than seventy-five per cent. of persons attacked die from the disease. Extensive eruption and multiple pustules render the prospect of recovery less favorable. In children and in feeble persons the disease is almost always fatal. Pregnant women are especially liable to abortion from the invasion of anthrax.

The prognosis in cutaneous anthrax bears a direct relation to the promptness and thoroughness with which the local lesion is treated. If the seat of the primary invasion be destroyed by efficient cauterization or complete excision before the bacilli have entered the lymph channels or gained access to the blood-vessels, a fatal result need seldom be apprehended.

When general infection of the system has occurred, the result is uniformly fatal. It is stated that but two cases of general anthrax are thus far known to have survived the disease (Leube and Massing).

Fagge states: "Hitherto, so far as I am aware, no instance of recovery from the intestinal form of anthrax has been recorded. In pulmonary anthrax the spleen is less subject to enlargement and softening than in any other form of the disease. The appearance of any illness of however trifling nature in a person exposed to the infection of anthrax should lead to a very guarded prognosis until such time as the disease may prove to be some other ailment. The greater number of cases of anthrax are fatal within four days from the appearance of the first symptoms. Pronounced febrile reaction with chill and a temperature above 102.5° F. would be a possible sign of successful resistance to the entrance of the bacilli into the general circulation, and the localization of the disease to the seat of invasion. No recorded case in which the presence of the bacilli in the blood has been proved has recovered."

PROPHYLAXIS.—As the diseased or dead body of an animal or a human being, and the substances emanating from the same, form the source of danger from anthrax, it is evidently important that these substances should receive special attention. The excreta or discharges of any kind from those sick with the disease should be carefully disinfected and burned, and the bodies of animals or human beings dying from the disease should be immediately wrapped in some efficient disinfectant and cremated. No post-mortem examination should be allowed, as thereby the opportunity for further infection is largely increased. The physician should warn the attendants, in cases of anthrax, of the danger of infection from the discharges of the patient. No person having a wound or abrasion on an exposed part of the body should take any part in the care of the patient, or touch anything which has been in contact with or near him. All bandages, dressings, etc., should be immediately burned. Especial attention should be given to the exclusion of flies and mosquitos, which have been proved to be the active carriers of various contagia. Unnecessary persons and all visitors should be rigorously excluded

The inoculation of the vaccines and toxins of anthrax is an efficient preventive of the disease in animals. Antitoxins may be curative, but no antitoxin is at present known which may be of service when the disease has passed its earliest stage. The blood serum from an immune animal, if injected subcutaneously into a susceptible animal, will afford a certain degree of protection against subsequent infection with anthrax. The following statement is from *Sajou's Annual* for 1898:

"A sheep was immunized until it could bear the injection of seven agar cultures with but slight elevation of temperature. A lamb was immunized likewise to the highest degree, and blood was taken from the carotid to obtain serum. With the serum of the sheep it was actually possible to save from death a rabbit in which an extremely virulent culture of anthrax was injected either

after or simultaneously with the serum. Evident therapeutic results were obtained with this serum in animals that had received the anthrax bacilli previous to the injection of serum. These results permit us to hope that anthrax in man and the domestic animals may sometime be treated by sero-therapy."

It is further stated that "French skins, since Pasteurian inoculation has been employed among the French flocks, have been found rarely to cause anthrax." *

Billings says: "Preventive inoculation seems an unjustifiable attempt in anthrax; that is, it is impossible."

Bell makes the following statement: "No efficient system in relation to the spread of anthrax has been yet possible. To accomplish this end there should be a careful separation of the infected wools, hair, hides, rags, etc., at their source, often in distant countries. This is manifestly very difficult to accomplish." In the subsequent handling of the materials during the processes of preparation and manufacture, every effort should be made to protect the workers from the dust arising from such materials, which should be removed by air draught and burned. Sterilization of all suspected substances by steam under moderate pressure has been found useful in the treatment of other infected substances, and would doubtless provide efficient protection against the disease. The vapor of formalin would probably be destructive to the germs of anthrax, and possesses the special advantage that the texture of the suspected materials is not injured by the process.

Fagge says: "The system of prophylaxis by inoculation of anthrax virus attenuated by transmission through suitable animals promises important results, and its study indicates a close analogy to the relation of cowpox to smallpox."

TREATMENT.—No treatment thus far known is of any avail in malignant pustule, unless it is employed at an early stage in the disease. The complete destruction of the pustule as soon as its nature can be recognized is the only measure upon which reliance can be placed. If this is not practicable by thorough excision, the carbuncle should be divided by deep incisions, and powerful caustics should be thoroughly applied (carbolic acid, nitric acid, chloride of zinc, bichloride of mercury, or the hot iron). This mode of treatment should be employed even when the disease has existed three or four days, as it has the power of destroying large numbers of bacilli, and may thus be supposed to modify the virulence of the disease, and possibly to allow of recovery in some cases which otherwise would end fatally. The resulting wounds should be treated in accordance with ordinary surgical rules. Internally, the treatment should embrace wine, champagne, coffee; and if signs of failure of the heart appear, carbonate of ammonia, camphor, etc., should be added.† If the disease has been induced by the use of infected meat, a prompt emetic should be administered, followed by a cathartic, for the purpose of removing the germs, as thoroughly as possible, from the alimentary canal before general infection of the system occurs. The only medicine which can be looked upon as in any sense a specific is quinine, of which 1 to 2 gm. should be prescribed in twenty-four hours, and it may be advantageously combined with carbolic acid, 1 gm. per day.

Carbolic acid, in a two to five per-cent. solution, may be injected into the diseased tissues in the amount of 1 gm. per day.

Strubell‡ reports a most interesting case of recovery from anthrax. The patient was a tanner, in whom the point of inoculation was the end of the nose. Owing to the seat of the lesion on the nose,—both it and the face generally being enormously swollen,—and to the serious general condition of the patient, operative treatment was not considered advisable. Treatment by subcutaneous injection of carbolic acid in three-per-cent. solution was commenced in and around the seat of the lesion, and into the enormously swollen and œdematous tissues in the neighborhood. Thirty Pravaz syringefuls were injected daily, thus introducing 0.9 gm. pure carbolic acid daily into the tissues. The same solution was also injected into the arm for its general effect, and the lesion was kept covered with *very hot* poultices, as were the parts around the seat of the disease. Stimulants and hot baths were also employed. For some days there was no apparent change in the condition of the patient, but afterward gradual improvement could be observed. The gangrene did not extend, and the œdema of the face and eyelids became less. The swelling of the neck, however, became more marked, and the number of injections was accordingly increased to thirty-six per day. By the end of three weeks, under this most energetic treatment and constant watchfulness, further extension of the disease was prevented. Only one small gland at the angle of the jaw suppurated. A ragged slough with fragments of adherent tissue was separated from the enormously enlarged and gangrenous nose, leaving a granulating surface, which quickly healed without leaving a visible scar. The bacilli of anthrax were readily found in the exudation from the primary lesion, but cultures from the blood never showed the organisms. The duration of the illness was between five and six weeks. The location of the primary lesion on the nose has not been previously reported, and this region is not adapted for the operative treatment of the disease. During eighteen days this patient received more than four hundred syringefuls of three-per-cent. solution of carbolic acid, but developed no symptoms of any toxic action from the drug. The urine was at times faintly tinged.

The poultice is supposed to act by elevating the temperature of the tissues to a depth of 1 to 2 cm. to such a degree as to render them unsuited for the growth of the anthrax bacillus, which cannot flourish at a temperature much above that of the human body. Thus, on external surfaces it is theoretically possible to exert an inhibitory influence upon the growth of the anthrax bacillus by the constant application of heat. The temperature of the poultice should not be less than 120° to 130° F., and the applications should be renewed at sufficiently frequent intervals to maintain nearly this degree of heat in the tissues at and around the lesion.

Scharnowski treated a series of twenty-eight cases of anthrax by subcutaneous injection of carbolic acid, with recovery in all cases. As much as 0.7 gm. per day has been reported as thus injected at one time without toxic symptoms. In anthrax it seems as if there were an increased toleration of carbolic acid.*

The constant use of ipecacuanha after excision of the local lesion, both by the mouth and by application to the seat of the pustule, has been followed by gratifying results in many cases.

In cases in which the limbs are the seat of extensive œdema or of gangrene, deep incisions should be made to allow the evacuation of the abnormal products, and antiseptic dressings should be rigidly adhered to until granulations have formed.

Increased familiarity with anthrax shows a striking similarity to other diseases dependent upon the introduction into the animal system of a specific organism of bacterial character, and the probable production of a specific toxin as the result of the physiological activity of the bacterial germ. From the results obtained in the study

* The total mortality from anthrax among inoculated animals, including that from the inoculations, was 0.94 per cent. for sheep and 0.54 per cent. for cattle. The animal loss before protective inoculation was practised is said to have been about 10 per cent. for sheep and 5 per cent. for cattle. ("Immunity and Serum-Therapy," 1895, p. 95.)

† Ipecacuanha locally and internally has also been highly recommended, and reports of recovery from its use have been published. Nucleinic acid has also yielded promising results in the hands of Vaughan.

‡ Münchener med. Wochenschrift, 1898, No. 48, p. 1526.

* In speaking of the use of carbonate of creosote in pneumonia, a compound similar in many ways to carbolic acid, Dr. Andrew H. Smith says: "The occasional smoky urine does not imply disintegration of blood corpuscles, as at one time supposed, but is the result of a harmless chemical reaction, and may be disregarded."—Medical News, December 16, 1899, p. 781.

of other specific organisms, affecting the human body or that of animals, it would seem reasonable to hope and expect that further research may furnish an efficient remedy in the form of an antitoxin in anthrax, such as has been obtained in respect to some other of the bacterial infections, particularly human diphtheria.*

The discovery of such an antitoxin has not, however, been announced; and the treatment of anthrax must still be considered as largely empirical or entirely symptomatic. This will vary according to the seat of the primary lesion, the severity and rapidity of the development of the disease, the possibility of employing efficient remedies locally, and many other circumstances which will arise in each individual case.

The treatment of the conditions following the immediate effects of anthrax, such as inflammatory and suppurative affections of the lungs or of other organs, should be directed by the considerations and principles applicable to the treatment of similar conditions arising from other causes.

The only practicable prophylactic measures which are adapted for general use among those subject to domestic visitations of anthrax, are to prohibit the use of any product or part of diseased animals; to protect the bodies of infected animals from flies and other insects, and to bury them as early as possible deeply in the earth, or preferably to burn them. Care should also be taken that none of the fluids or secretions of diseased or dead animals be allowed to soil the stables or yards where they have been confined, nor to cling to implements, such as shovels, etc. The fæces, being loaded with bacilli, should be carefully collected and buried. All stalls and stables visited or occupied by diseased animals should be carefully disinfected and whitewashed. Other suitable precautions which may be applicable to individual cases should be rigorously carried out, as the best safeguard against the spread of the disease among human beings is to control it among the lower animals. The precautions to be observed in relation to infected articles of commerce—hides, hairs, wool, rags, etc.—have been mentioned in an earlier part of this article.

Albert N. Blodgett.

The literature upon the subject of anthrax is very large, but among the most valuable contributions may be mentioned:

Heusinger: Die Milzbrandkrankheiten der Thiere u. des Menschen, Erlangen, 1850.
Bollinger: Art. Milzbrand in v. Ziemssen's Handbuch.
Waldeyer: Virchow's Arch., Bd. iii., S. 541.
Zuelzer: Berl. klin. Wochenschrift, 1874, No. 25; also in Eulenburg's Realencyclopädie, vol. ii., p. 679.
Quain: Dictionary of Medicine, p. 1302.
Forbes: International Encyclopædia of Surgery, vol. i., p. 228.
Holmes' System of Surgery, vol. v., p. 467.
John Henry Bell, in Allbutt's System of Medicine (contains a valuable list of references). Traité de Médecine. Charcot, Buchard, Brissaud, vol. i., p. 523.
Fagge: Principles of Practice of Medicine, vol. i., p. 367.
Twentieth Century Practice of Medicine, vol. xv., art. Anthrax.

ANTHROPOMETRY. See *Recruiting Service* and *Skull.*

ANTIARTHRIN is a condensation product of tannic acid and saligenin, one of the decomposition products of salicin. It has been found by Schaeffer to be of value in acute and chronic gout and acute rheumatism, it possessing the advantages of not deranging the stomach and not depressing the heart. The compound is very unstable, and, to prevent decomposition, it must be kept dry and free from admixture with other drugs. Dose: fifteen grains, from three to six times a day. *W. A. Bastedo.*

ANTIDIABETINUM.—Glycosolveol. A name applied to a series of three mixtures of mannite and saccharin, each mixture having a definite sweetness in proportion to that of cane sugar. Antidiabetinum No. 1 has the same sweetening power, No. 2 is ten times as sweet, and No. 3 is seventy times as sweet as sugar. They are used as substitutes for sugar in diabetes. *W. A. Bastedo.*

* "How far this principle will be found capable of general application in infective diseases and whether pathologists will be successful in discovering the necessary modes of attenuation and cultivation the future will show. The outlook is certainly most hopeful."—Prof. J. A. Lindsay: Lancet, December 30, 1899, p. 1799.

ANTIDOTES.—(Deriv., ἀντί and δίδωμι.) Antidotes are remedies which, acting mechanically, chemically, or physiologically, are capable of combating and neutralizing the effects of poisons on the system. They may be divided into three classes, according to their mode of action: (1) mechanical, (2) chemical, and (3) physiological or dynamic.

1. Mechanical Antidotes.—The functions of this class are the removal of poisons as such from the system and the mechanical prevention of absorption. In this class are included emetics, stomach tube, cathartics, injections, washes, poultices, ligature, tourniquet, etc.

The use of *emetics* is frequently rendered superfluous by the vomiting induced by the poison itself or by the diluent drinks already administered. Where there exists any considerable corrosion of the œsophagus or stomach, or severe abdominal inflammation, their use is contraindicated. When employed they should be administered without delay, and vomiting should be carried on to such completeness as circumstances will allow. The nature of the poison in each particular case must to a certain extent govern the choice of the emetic to be prescribed. Thus, common salt is contraindicated in poisoning by tartar emetic or by corrosive sublimate, and oily substances in poisoning by phosphorus, cantharides, and salts of copper. The emetics include sulphate of copper, sulphate of zinc, tartar emetic, ipecac, emetin, apomorphine, soapsuds, olive oil, melted fats, snuff, etc. In most cases, vomiting may be induced, encouraged, and supported by tickling the fauces with the finger.

Sulphate of copper may be administered in doses of 0.12 to 0.30 gm. in water. Sulphate of zinc is a very efficient emetic in doses of 1.0 to 2.0 gm. in 250 gm. of water. Tartar emetic is slow in action, and it exercises so depressing an effect on the system as to render its use inadvisable when emesis can be otherwise produced. If administered it should be given in 0.1 gm. doses, once or twice repeated if necessary. Ipecac is best given in the form of powder, the action of the wine and of the fluid extract being too uncertain. The powdered root may be given in 1 to 2 gm. doses in warm water, or it it may be combined with tartar emetic in the proportion of 1 to 0.05 gm. The alkaloid emetine is an efficient emetic in doses of 0.005 to 0.020 gm. Apomorphine is in many cases the only emetic possible to introduce, especially when there is resistance or trismus. It is not only a very powerful emetic, but it acts with great rapidity. It is administered by subcutaneous injection in doses of 0.004 to 0.010 gm. The common household remedies, salt, mustard, soapsuds, etc., are frequently of great assistance, and they possess the advantage of availability. Common salt is effective when given in the proportion of two tablespoonfuls to a pint of water; mustard in doses of two teaspoonfuls in a cup of warm water; snuff, one teaspoonful in warm water or claret. Olive oil, soapsuds, etc., require no especial mention.

It frequently happens, especially in poisoning by narcotics, that even the most powerful emetics are inoperative. In such cases the *stomach pump* is a very valuable aid. This instrument has certain advantages over the emetics; the object is attained more quickly, the patient is spared the weakening effects of the emetics, and fluids may be introduced not only for washing out the stomach but for their chemical action on any residuum adherent to the stomach wall. Should the instrument be not readily obtainable, one may use a common rubber tube to one end of which a funnel is attached. To use this very excellent substitute is a matter of no great difficulty; introduce the free end into the stomach, elevate the other end, and pour water or other fluid through the funnel until the stomach and tube are full; then lower the funnel end to make a siphon, and allow the contents of the stomach to escape into a proper vessel. The employment of the stomach pump is not permissible when the œsophagus and stomach are corroded, on account of

the danger of perforation. The instrument is also of no value when the poisonous substance is in the solid form and in large pieces (meat, sausage, cheese, etc.).

Cathartics are frequently necessary when the poison has passed from the stomach into the intestine. Those in most common use are castor oil, croton oil, Epsom salts, senna, etc. Castor oil not only acts as a cathartic, but protects the mucous membranes and obstructs absorption. Its use is contraindicated in phosphorus and cantharides poisoning, since the absorption of these substances is materially assisted by fats and oils. Croton oil is valuable by reason of its rapid and powerful action. It is best given in pill form (bread crumb) in doses of one to four drops. Sulphate of magnesium in doses of 4 to 16 gm. (ʒi.–iv.) is recommended in chronic lead poisoning, and in connection with certain of the chemical antidotes as an aid in the removal of the resulting compounds from the alimentary canal. Gamboge, croton oil, and other drastics are to be preferred to the cathartics of milder action in narcotic poisoning.

The other physical antidotes above mentioned are employed according to the circumstances of particular cases. Their use is limited almost wholly to poisoned wounds and bites.

2. CHEMICAL ANTIDOTES.—These constitute the class of true antidotes; they act on the poisons themselves rather than against their effects, differing in this respect from the dynamic or antagonistic antidotes. Their action depends upon their property of uniting chemically with poisonous substances, thus altering their chemical and physical character, converting soluble absorbable substances into insoluble or difficultly soluble non-absorbable compounds, or, as the case may be, into compounds which are soluble and absorbable, but harmless. Their use is restricted to those cases in which the nature of the poison is known. Good chemical antidotes should be themselves harmless, even in large excess, easily obtainable, and capable of rapid action. Their employment should not be unnecessarily delayed nor too long continued. They are usually administered in large doses, since it is as a rule impossible to determine the necessary amount with any exactness, but in certain cases the amount given must be carefully regulated, on account of the solubility of the resulting compound in an excess of the antidote; instances illustrative of this point are copper salts with albumin, and the alkaloids and their salts with tannin. In all cases the new-formed compounds, especially when only temporarily insoluble, or insoluble only in the stomach, must be removed by appropriate means with all possible despatch.

The antidotes of this class are divided into (*a*) Organic, and (*b*) Inorganic.

(*a*) *Organic Chemical Antidotes.*—These antidotes are derived from the animal and vegetable kingdoms, and include substances of widely diverse character. The most important are albumin, milk, gelatin, charcoal, soap, tannin, turpentine, oils, etc.

First in importance is *albumin*, which is adapted to very general use, especially against the inorganic poisons. It is in most cases very easily obtained, it never causes of itself any harm, and it forms more or less insoluble compounds with most metallic salts and mineral acids. Orfila recommended its invariable use, even on mere suspicion of poisoning. It is best administered in fairly dilute form, the whites of four eggs to a quart of lukewarm water. When taken in sufficiently large amounts, it not only unites with the poison to form insoluble compounds, but provides a protecting coating for the mucous membrane, and at the same time may induce vomiting. With hydrochloric, nitric, and sulphuric acids it produces coagula which are more or less soluble in large amounts of water; with phosphoric, acetic, tartaric, and the organic acids generally (tannic excepted), no precipitation occurs. With the corrosive alkalies albumin forms soluble, harmless compounds when given in copious draughts. It forms insoluble albuminates with the alkaline earths and soluble compounds with potassium and sodium. The alums, tartar emetic, and compounds of arsenic are not precipitated. Iodine, bromine, and chlorine unite directly and intimately with the antidote to form harmless compounds. With phosphorus its action is very limited, and of no especial value except as a diluent drink. The presence of any large excess of alkali acts in general to prevent the precipitation of the albumin compounds. The precipitates of albumin with the salts of the heavy metals consist either of a compound of albumin with a basic salt, or, as it is claimed, of a mixture of the metallic albuminate with a compound of albumin and the acid of the metallic salt. They are usually soluble in acids and alkalies, and insoluble in excess of albumin. Notable exceptions are the compounds with mercury and copper, which are soluble in a considerable excess of the antidote. The compounds with salts of lead, copper, and zinc are easily dissolved in lactic, acetic, and other organic acids, and in free alkalies. In the case of sulphate of zinc, however, which is precipitated only in very great excess of the antidote, the precipitation is hastened, and rendered more complete, by the addition of a small amount of free alkali. Silver salts are easily precipitated; the resulting compounds are partially soluble in excess of common salt. The precipitate with corrosive sublimate is easily soluble in mineral and organic acids, common salt and similar chlorides, somewhat soluble in sodic phosphate and in large excess of albumin. The precipitates of the other mercuric salts are less soluble in the same solvents; the mercurous salts are reduced to the metallic form. Other salts with which albumin unites are those of gold, platinum, zinc, antimony (except tartar emetic), and iron. Among the organic poisons which unite chemically with albumin are creosote, aniline, and alcoholic solutions of most of the alkaloids.

In case albumin is not obtainable, recourse may be had to *milk* as a substitute; its action is due to its casein, albumin, and free alkali. Administered lukewarm it is very valuable in poisoning by metallic salts, corrosive acids and alkalies (especially ammonia), and the alkaline earths. Its richness in fat contraindicates its use where fatty substances are to be avoided.

The value of *gelatin* as an antidote to many metallic salts would be greater if less time were required for its preparation in a suitable form for administration. It must be broken up into small pieces, covered with water, and allowed to soak for about an hour; more water is then added, and the mixture is heated with constant stirring until a fluid of the consistence of honey is obtained. Its chief value is in poisoning by iodine, bromine, and the alums.

Tannin, and substances containing it, act as efficient antidotes to many of the organic and inorganic poisons. Tannin forms more or less insoluble compounds with many metallic salts, but it cannot be considered as equal to albumin in efficiency as an antidote to this class of poisons. Tartar emetic is, however, a notable exception since it is unaffected by albumin, but rendered harmless by tannin, with which it forms an almost insoluble compound. Tannin has considerable value as an antidote to the vegetable poisons; it precipitates the alkaloids and their salts, and forms compounds which are dissolved only with difficulty. These compounds are of themselves poisonous, and hence must be removed from the system as soon as possible by emetics, drastic purges, or the stomach tube. Tannin may be given in doses of 0.1 to 0.3 gm. in two-per-cent. solution every quarter of an hour. Combined with about one-tenth of its weight of iodine its effect on the vegetable poisons is very much increased. Should tannin itself be not easily obtained, decoctions of substances containing it may be substituted. Among the large number of these may be mentioned tea, coffee, oak bark, willow, cinchona bark, nutgalls, kino, rhatany, and catechu.

Sugar has been recommended in poisoning by the alkaline bases, with which it is supposed to form sucrates. It has also been recommended in poisoning by salts of copper, but just what value it possesses in

such cases would be difficult of determination. It is perhaps safe to say that its value with copper salts is *nil*.

Oils possess more or less value in poisoning by corrosive alkalies, metallic oxides and salts, corrosive acids, and carbolic acid. They may be administered alone or with hot water. (Contraindicated by phosphorus and cantharides.) With the caustic alkalies they unite to form soaps with liberation of glycerin. Their action is, however, slow, and they are on this account of less value than the organic acids in poisoning by alkalies. They are also inferior in value to albumin in the treatment of poisoning by metallic salts. The oils most commonly used as antidotes are olive, cotton seed, linseed, and almond; also melted butter and lard.

Starch in the form of paste (one part of starch to ten or twenty of water) is a suitable antidote to iodine and bromine, with which it forms intimate and almost harmless compounds. Its affinity for iodine is less than that of albumin, and the latter is preferable when obtainable. It has some value, but by no means as much as albumin, in the treatment of poisoning by corrosive acids, corrosive sublimate, sulphate of copper, and sulphate of zinc.

Mucilage and mucilaginous drinks, though exerting more or less chemical action, are administered chiefly as protectives against corrosion. They are best made from gum arabic, which is rubbed up with water. Mucilage in copious draughts has been recommended specially for the treatment of poisoning by salts of bismuth.

The use of *turpentine* as an antidote is confined exclusively to poisoning by phosphorus, against which it is beyond question the most valuable remedy. To be capable of acting beneficially it must contain oxygen, which it absorbs with age. When needed, it should be given with all despatch, either alone or in hot water, in doses of about one hundred times the supposed amount of phosphorus ingested.

Charcoal. In addition to its power of absorbing gases, freshly prepared animal charcoal has, according to many writers, considerable antidotal value in poisoning by metallic salts, phosphorus, and many of the alkaloids. Many consider its value to be restricted to its protective influence on the walls of the stomach. The latter view would seem to be the more reasonable, especially when one considers that the antidote enters into no fixed compounds with mineral or vegetable poisons. Whatever its action on the poisons, however, it cannot be denied that their effects are postponed and considerably slowed. It may be administered in repeated doses of about a tablespoonful, in water, with or without sugar.

Whatever value it has as an antidote is possessed also by wood charcoal, though in a lesser degree.

Soap dissolved in warm water, and in this form administered by the cupful at intervals of a few minutes, is very useful in poisoning by acids and metallic salts, especially corrosive sublimate, bichromate of potassium, and salts of tin and zinc. In contact with inorganic acids the alkaline stearates, palmitates, etc., are decomposed with the liberation of the fatty acids and the union of the alkali of the soap with the acid against which the influence of the remedy is directed. The same result obtains with the metallic salts, except that the metal forms compounds with the fatty acids. This antidote is preferable to the caustic alkalies, since it exerts of itself no corrosive influence; it is, however, much inferior in value to albumin in most cases.

(*b*) *Inorganic Chemical Antidotes.*—In the administration of this class a more or less exact knowledge of the nature of the poison is even more necessary than for the exhibition of the organic class. The attempts which have been made to compound a universal antidote which would, of course, be equally valuable with or without the knowledge of the nature of the poison, are very numerous, but such an antidote has not been as yet, and it is safe to say never will be, discovered. These attempted general remedies have in most cases consisted chiefly of substances belonging to the class now under consideration, and several of them are of considerable value, especially when the nature of the poison is unknown. One of the number consists of equal parts of magnesia, oxide of iron, and wood charcoal; it may be administered freely in moderately large amounts of water. Another, suggested by Jeannel, consists of 2 parts of calcined magnesia, 1 part of washed animal charcoal, 20 parts of water; when administered it is to be mixed with 2.5 parts of ferrous sulphate solution (specific gravity, 1.450) and well shaken. Given in doses of a wineglassful it is itself harmless, and may be productive of much good. When the nature of the poison is, however, known, and an antidote of the inorganic class is indicated, the appropriate remedy is usually exhibited unmixed with other than inert substances (vehicles, diluents, etc.). The antidotes of this subdivision include the following:

Acids. The acid antidotes belong, strictly speaking, to both the subdivisions (*a*) and (*b*), since they include both organic and inorganic compounds. The organic acids indeed are the ones most commonly used, yet for convenience' sake, and on account of other obvious considerations, it would seem not inappropriate to consider both kinds together, with the single exception of tannic acid, which is of sufficient importance to be classed alone. Their principal use is in dilute form as neutralizing agents in poisoning by the alkalies and alkaline carbonates. For this purpose the most commonly used are acetic (vinegar), citric (lemon juice), and tartaric. Very dilute sulphuric acid (one per cent.) is used as a prophylactic against painter's colic, and also in the active treatment of poisoning by soluble salts of barium and lead, with which it forms insoluble sulphates. The vegetable acids are employed also dynamically in the after-treatment of narcotic poisoning.

Ammonia as an inhalation is valuable in poisoning by chlorine, bromine, vapors of corrosive acids, hydrocyanic acid, and nitrobenzol. It is best to dilute the remedy very considerably in order to lessen the pungency of the vapor.

Sodium and potassium carbonates in dilute form may be used as neutralizing agents in poisoning by acids, in the treatment of which, however, they are less valuable than the carbonate of magnesium, since they are less easily tolerated by the stomach. Their employment is still further prejudiced by the fact that in large doses they may cause more or less injury. The mildest in their effects are the bicarbonates, which are at the same time the more easily obtained. Their use as antacids is sometimes accompanied by the development of such an amount of carbonic acid as to cause distress by distending the stomach. They are contraindicated in poisoning by oxalic acid with which they form compounds equally dangerous. Besides their function as antacids they may be used very advantageously in poisoning by iodine and bromine, with which they form harmless salts. Bichromate of potassium, when treated with alkaline carbonates, is converted to the neutral chromate. The majority of poisonous metallic salts may be decomposed by the bicarbonates, the resulting products being basic carbonates and hydrates, which are insoluble in excess of the reagent. They are recommended particularly in poisoning by the salts of zinc, which are precipitated only incompletely by albumin in large amounts; these salts are immediately decomposed by the bicarbonates with which they form insoluble basic carbonates.

Hydrate and carbonate of calcium (lime water, chalk, egg shells, pounded oyster shells, etc.). These compounds are efficient antidotes in poisoning by the acids, both mineral and organic. They have especial value in poisoning by oxalic acid and the acid oxalates, which substances they not only neutralize, but convert to insoluble calcic oxalate. The sucrate of calcium has also been recommended, but it possesses no particular advantages.

The *hydrate and carbonate of magnesium* are beyond question the most efficient and valuable antidotes to the acids and acid salts. Whenever possible it is advisable

to administer these preparations in preference to the other antacids already mentioned, except with oxalic acid and the acid oxalates. In the absence of the calcium preparations, however, they may be productive of very good results in the treatment of oxalic poisoning, the resulting oxalate of magnesium being very nearly insoluble. They are superior in value to the carbonates of sodium and potassium in poisoning by bromine, iodine, and bichromate of potassium. The hydrate was recommended by Mandel as early as 1808 as an antidote to arsenic, and by Graf and Berzelius in 1814 as an antidote to arsenic and mercury. By Paulus and Schuchard it was recommended against corrosive sublimate and other metallic salts. It has been recommended also against phosphorus, especially in connection with the hypochlorite. In contact with solutions of metallic salts its action is to precipitate the corresponding oxides or basic salts. With the arsenic acids it combines to form compounds which are almost completely insoluble in the alimentary canal.

The so-called magnesia of the apothecaries is a compound of magnesic carbonate with magnesic hydrate and water, or a basic carbonate of magnesium. This substance when gently heated parts with its water and carbonic acid, leaving a residue of calcined magnesia, which is slightly soluble, and which, when mixed with about twenty-five times its weight of water, becomes gelatinized, and is then in the proper form for antidotal use. In the process of calcining it is essential that the temperature be kept as low as possible, since when prepared at a high temperature it loses its property of gelatinizing with water. The hydrate may be prepared by precipitating a solution of sulphate of magnesium with sodic hydrate free from carbonate. The precipitate, after being well washed, may be dried out of contact with the air at a temperature below 100° C.

In the administration, in case of poisoning by arsenic, the preparation made from pure calcined magnesia with twenty-five times its weight of warm water may be given in doses of about 45 to 60 gm. (℥ iss. to ij.) at short intervals, then, after a few doses, at longer intervals, until the immediate symptoms disappear, and the magnesium appears abundantly in the fæces. A large excess can do no harm; it acts, indeed, beneficially by stimulating catharsis. In the administration of the compounds of magnesium for their antacid effects it is well to give a considerable excess, which is tolerated without difficulty.

Sulphates of magnesium and sodium (Epsom and Glauber's salts) have especial value in poisoning by soluble salts of barium and lead. The removal of the insoluble sulphates which are precipitated is materially aided by the cathartic action of the excess of the antidote. Their administration may be continued until purging occurs or until the symptoms abate or disappear.

Chloride of sodium (common salt) is perhaps the best antidote to the soluble salts of silver. It should be given in somewhat dilute solution, since concentrated salt solution will dissolve considerable amounts of chloride of silver. By some writers albumin is considered preferable to salt; by others it is recommended to give both together; and by still others to administer both singly, the albumin following the salt.

Ferrocyanide of potassium forms insoluble or difficultly soluble compounds immediately on addition to solutions of many salts of the heavy metals. It is in itself a comparatively harmless substance; in large doses it may cause marked dizziness. It is especially valuable in poisoning by salts of copper, in the treatment of which Orfila found it to give as good results as are obtained with albumin. It is not, however, to be preferred to the latter, which is, if only equal in efficiency, certainly more easily obtained. The ferrocyanide may be given in repeated doses of 2 to 5 gm. in water.

Chlorine. The value of chlorine is considerably lessened by its very irritant effects on the mucous membranes. It may be used externally in the form of chlorine water, hypochlorite of sodium (Labarraque's fluid), or hypochlorite of potassium (eau de Javelle), as a wash for snake bites and other poisonous wounds. The above-named preparations may be used in dilute form, both internally and as sprays for inhalations; internally, in poisoning by alkaloids and vegetable and animal poisons; as inhalations, in poisoning by coal gas (carbonic oxide), ammonia, phosphoretted hydrogen, sulphuretted hydrogen, and prussic acid.

Chlorine water may be administered internally in doses of 4 to 16 gm. (ʒ i. to iv.) largely diluted; as a spray for inhalation, a solution of five to ten drops in water. The hypochlorites of potassium and sodium may be administered in doses of 4 to 8 gm. (ʒ i. to ij.), well diluted with water.

Iodine possesses considerable value in the treatment of poisoning by the alkaloids and their salts, by other vegetable poisons, and by snake bites. It unites with most of the alkaloids to form compounds which are insoluble in water and dilute acids but are decomposed by the caustic alkalies, alkaline carbonates, and strong acids. The compounds of the vegetable poisons with iodine are possessed of more or less poisonous properties, and are therefore to be expelled from the system by appropriate means; they are, of course, much less poisonous than the pure bases. Since iodine is itself a very energetic poison, it must be given in very dilute form. The preparation recommended by Bouchardat, and by him considered particularly effective against the vegetable poisons, consists of iodine, 0.20 gm.; iodide of potassium, 2 gm.; and distilled water, 360 gm.; the dose is from 50 to 100 gm., frequently repeated according to circumstances. Iodide of potassium is much used as an antidote in the elimination of lead and mercury from the system in cases of chronic poisoning.

Bibron's antidote to the poison of serpents is a mixture of iodide of potassium, 0.016; corrosive sublimate, 0.130; and bromine, 20 gm. Given in good season and in repeated doses of ten drops in wine or brandy, it has been proved to be effectual.

Hyposulphite of sodium in doses of 1 gm., well diluted and frequently repeated, is valuable in poisoning by bleaching powder (hypochlorite of calcium, "chloride of lime"), Labarraque's fluid (hypochlorite of sodium), and Javelle water (hypochlorite of potassium). Its action is to reduce the hypochlorites to chlorides, itself undergoing oxidation to the sulphate.

Sulphuretted hydrogen has been recommended as an antidote to arseniuretted hydrogen, but its efficacy is yet to be proven.

Iron. The hydrated sesquioxide of iron is the most efficient antidote to arsenic when the latter is ingested in soluble form. It was first recommended in this connection in 1834 by Bunsen and Berthold, who proved its efficiency by numerous experiments on dogs and other animals. With arsenious anhydride (white arsenic) it forms, according to Bunsen, a basic arsenite of iron, which is but slightly soluble in the fluids of the digestive tract, but which, on account of its not unpoisonous character, must be removed from the body with all despatch by promptly acting cathartics. By later writers the compound which is formed is considered to be a ferrous arseniate. The union with arsenic is very complete; if an amount of the antidote representing ten parts of ferric oxide be added to one part of arsenic, the filtrate will not reveal even a trace of the poison. In addition to its combining action, it possesses a certain value as a protection to the stomach and intestines against the injurious local effects of the poison. With the arsenic anhydride, and the arsenious and arsenic salts, the union is very limited, even with very large excess of the antidote; the effect is much increased by the addition of a small amount of ammonia or other caustic alkali. In poisoning by the arsenites and arseniates a mixture of the hydrated sesquioxide with basic acetate of iron is more effective. The hydrated sesquioxide is easily prepared by adding ammonia water, sodic or potassic hydrate, sodic or magnesic carbonate, to a solution of ferric chloride or sulphate, or to the tincture of the chlo-

ride (tinctura ferri chloridi). The precipitate is thoroughly washed and then mixed with a rather large amount of water. The directions of Bunsen and Berthold for its preparation are to add a small amount of sulphuric acid to a solution of 100 gm. of ferrous sulphate, then nitric acid, and boil; when cold add an excess of ammonia water, filter and wash, and mix the precipitate with 900 gm. of water. It is rather better, however, to obtain the antidote by the addition of carbonate of magnesium to a solution of ferric sulphate and avoid filtering and washing; one of the products of this operation is sulphate of magnesium, which adds to the value of the antidote by virtue of its cathartic action.

Since the freshly prepared hydrated sesquioxide undergoes gradual changes which lessen its effectiveness in a very material degree, it is advisable when possible to prepare it as occasion demands. The stability is in direct proportion to the care in preparation and the purity of the iron salt. Since all warming is to be avoided in the preparation, the solutions used must be considerably diluted. If the antidote is to be preserved for cases of emergency, it is best kept in a cold place and well stoppered.

In the administration of this antidote there are certain points which are to be kept in mind; the poison should be removed from the stomach as completely as possible by emetics or the stomach tube; the antidote should be freshly prepared if possible, and should be given lukewarm and in large doses (30 to 60 gm.) at first, at intervals of about ten minutes, and later at longer intervals, until the symptoms disappear and iron appears in the stools. It is perhaps needless to say that treatment should be begun as soon as possible. It is well to follow up the treatment with an active cathartic, on account of the poisonous character and slight solubility of the resulting compound. It has been well shown experimentally by Schroff, that when the latter substance is itself administered to animals, arsenic may be detected in the urine.

Basic acetate of iron, dialyzed iron, and saccharated iron (ferrum oxydatum saccharatum solubile) have been used with varying success in poisoning by arsenic and arsenious compounds.

Iron filings and reduced iron have, it is claimed, been used with good effect in poisoning by salts of gold, mercury, copper, and other metals. Dose, 2 to 10 gm. frequently repeated. Sulphide of iron has been proposed as an antidote to mercury, lead, antimony, copper, gold, platinum, tin, arsenic, and other metallic salts, but its value is not proven.

Carbonate of copper in repeated doses of 0.25 to 0.50 gm. with sugar and water has been recommended in acute phosphorus poisoning, following an emetic. It is supposed to act upon the particles of phosphorus in such a way as to prevent their solution by furnishing them first with a layer of phosphide of copper, and later with one of the metal itself. Its use is to be preceded and followed by emetics.

3. THE PHYSIOLOGICAL OR DYNAMIC ANTIDOTES are remedies employed to combat the symptoms or after-effects, and to neutralize the effects of poisons after absorption into the system. As their name implies, they do not act on the poison themselves chemically, mechanically, or otherwise. Consideration of the individual members of this class is beyond the scope of this article and comes more properly under the head of therapeutics.

Charles Harrington.

ANTIDYSPEPTIC AND TONIC SPRINGS.—Nottoway County, Virginia.

POST-OFFICE.—Burkeville.

ACCESS.—Via Norfolk and Western Railroad, thence one half mile to springs. Small hotel and boarding houses.

These springs are located in a fine, salubrious region about 530 feet above the sea level. They are two in number, the flow from the main spring, No. 1, being about 240 gallons per hour. The water was analyzed in 1890 by Prof. E. T. Fristoe, of the Columbian University, with the following results:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium hydrate (?)	0.51
Sodium chloride	0.28
Magnesium chloride	0.20
Magnesium carbonate	0.94
Magnesium sulphate	1.30
Calcium sulphate	0.46
Iron oxide	Traces.
Aluminum	0.16
Lithium	Traces.
Calcium carbonate	1.65
Nitric acid	Traces.
Organic matter	Traces.
Sulphuric acid	Traces.
Phosphoric acid	0.78
Silica	1.89
Total	8.17

Free carbonic acid gas, large amount.

The acids and elements expressed in the table are undoubtedly in combination. The water has an extensive reputation in the treatment of dyspepsia and intestinal disorders. It is believed to possess useful properties as a tonic. It may be classified as a light sulphated saline. The water of Spring No. 2 contains about ten grains of solid matter per United States gallon, including enough iron to make it a valuable chalybeate. It is warmly recommended as a ferruginous tonic. These waters are bottled and sold, being shipped to any desired point.

J. K. Crook.

ANTIKAMNIA is a proprietary name for a whitish powder which is claimed by the makers to be a mixture of coal-tar products, and found by various analyses to contain acetanilid and sodium bicarbonate, with or without caffeine. Its dose, as an analgesic, is from five to ten grains. *W. A. Bastedo.*

ANTIMONY.—1. GENERAL MEDICINAL PROPERTIES OF COMPOUNDS OF ANTIMONY.—As usual with compounds of the heavy metals, all antimonials capable of absorption produce essentially similar constitutional effects. These effects are, in medicinal dosage, depression of pulse in both force and frequency, with fall of arterial tension, diaphoresis, increase of mucous secretions, and, with rise of dosage, nausea and vomiting, with decided muscular debility. In large doses antimonials are powerfully poisonous, causing heart failure, prolonged and violent vomiting and purging, with cramps, and general collapse. Locally, soluble antimonials, such as that most commonly used preparation of antimony, *tartar emetic*, are irritant—much of the emetic effect being evidently due to local irritation of the stomach upon swallowing. Concerning the rationale of the production of the various effects described, the only points of clinical importance are that the effects upon the pulse seem to arise from a direct depressing action upon the heart, and not secondarily from a possible excitation of the restraint influence exerted through the vagus nerve, and that the vomiting seems to be induced partly by direct local irritation of the stomach, and partly by an action upon the nerve centres, after absorption. For tartar emetic vomits when injected into the veins, but yet not so readily as when given by swallowing.

Therapeutically, antimonials generally are used to depress the pulse in sthenic fever, to hasten the secreting stage in respiratory catarrhs, empirically to oppose the inflammatory process—most notably again in respiratory inflammations, such as pneumonia, and, possibly, to determine vomiting.

2. THE PREPARATIONS OF ANTIMONY USED IN MEDICINE.—The antimonials of the United States Pharmacopœia are derived from three compounds of the metal, namely, *antimonious oxide*, *antimonious sulphide*, and *potassio-antimonious tartrate*.

Antimonious Oxide, Sb_2O_3.—Antimonious oxide is official as *Antimonii Oxidum*, Antimony Oxide. It occurs

as "a heavy, grayish-white powder without odor or taste, and permanent in the air. Almost insoluble in water, and insoluble in alcohol. Nitric acid fails to dissolve it, but it is readily soluble in hydrochloric acid without effervescence, and also in a warm solution of tartaric acid, or in a boiling solution of potassium bitartrate" (U. S. P.). Antimonious oxide exerts the general properties of the antimonials, but is uncertain, doubtless because from its insolubility it must undergo chemical conversion in the stomach before absorption is possible. It is rarely prescribed except in the official preparation, entitled:

Pulvis Antimonialis, Antimonial Powder; "James' Powder." This powder consists of thirty-three parts of antimony oxide, intimately mixed with sixty-seven parts of "precipitated calcium phosphate." It is white in color, and from the insolubility of its two ingredients is without taste. It is a generally mild but yet uncertain antimonial, available for the antifebrile purposes of the mineral. Dose, for such use, from 0.20 to 0.50 gm. (gr. iij.–viij.) every few hours.

Antimonious Sulphide, Sb_2S_3.—Under the title *Antimonii Sulphidum*, Antimony Sulphide, the U. S. P. makes official "native antimony sulphide, purified by fusion and as nearly free from arsenic as possible." This is the compound commercially known as *antimony*, or *crude antimony*. It is in conical masses of metallic appearance, which, pulverized, yield a dull, black, odorless and tasteless powder, insoluble in water or alcohol. It is official as the source of the following preparation, which, again, is used only pharmaceutically to yield still another:

Antimonii Sulphidum Purificatum, Purified Antimony Sulphide. The sulphide above described is finely pulverized, the coarser particles separated by elutriation and rejected, and the finer macerated in ammonia water for five days, then washed and dried by heat. By these manipulations impurities in the native sulphide are gotten rid of, the ammonia serving to dissolve out copper, a common contamination. The purified sulphide is a dark-gray powder of the qualities already detailed. It is used to make the following:

Antimonium Sulphuratum, Sulphurated Antimony. "Kermes Mineral." The purified sulphide is boiled in diluted solution of soda, the liquid strained, and while still hot precipitated by diluted sulphuric acid. The precipitate is then washed, dried, and finely pulverized. It appears as a reddish-brown, amorphous powder, odorless and tasteless, and insoluble in water and in alcohol. In composition it is "chiefly" antimonious sulphide, "with a very small amount of" antimonious oxide. Like all the insoluble antimonials, its medicinal action is uncertain, and the preparation is rarely prescribed except as it occurs in the following official pill:

Pilulæ Antimonii Compositæ, Compound Pills of Antimony; "Plummer's Pills." These pills are compounded of one part each of sulphurated antimony and calomel, and two parts of guaiac. Each pill weighs 0.16 gm. (about 2.5 grains). This preparation had an ancient reputation in the treatment of secondary syphilis, scaly skin eruptions, chronic rheumatism, etc. One or two pills constitute a dose, to be given twice a day.

Potassio-antimonious Tartrate, $2K(SbO)C_4H_4O_6+H_2O$. —This salt, so well known by the name *tartar emetic*, is official under the title *Antimonii et Potassii Tartras*, Antimony and Potassium Tartrate. It is commonly made by boiling together in water antimonious oxide and acid potassium tartrate (cream of tartar), and obtaining the resulting double tartrate by crystallization from the solution. Other methods, however, are resorted to by some manufacturers. Tartar emetic occurs as "colorless transparent crystals of the rhombic system, becoming opaque and white on exposure to air; or a white granular powder, without odor, and having a sweet, afterward disagreeable, metallic taste. Soluble in seventeen parts of water at 15° C. (59° F.) and in three parts of boiling water, but insoluble in alcohol, which precipitates it from its aqueous solution in the form of a crystalline powder" (U. S. P.). Aqueous solutions of tartar emetic spontaneously decompose, and are precipitated by acids, alkalies, and alkaline carbonates, soluble salts of lead, and vegetable astringent preparations, such as infusion of galls.

In modern medical practice in the United States tartar emetic is practically the only antimonial used, and is available for all the effects of antimony as already described. In doses of about 0.005 gm. (gr. $\frac{1}{12}$) it depresses the heart and promotes secretion; in doses of about 0.01 gm. (gr. $\frac{1}{6}$), repeated, it nauseates, and in doses of from 0.03 to 0.12 gm. (gr. ss. to ij.) it vomits, with the usual prolonged and distressing attendant nausea of the antimonials. In quantities beyond those last mentioned it is a dangerous and easily fatal poison. It may be given in aqueous solution, and if employed to provoke vomiting, should be prescribed in doses of 0.03 gm. (gr. ss.), to be repeated every fifteen minutes until vomiting ensue, or until four doses have been taken. When wanted in small dosage for catarrhs or fevers, the official *Vinum Antimonii*, Wine of Antimony, is more commonly prescribed. To make this wine, four parts by weight of tartar emetic, dissolved in a little boiling water, is added to fortified white wine in such quantity as to yield 1,000 parts by measure of product (about gr. 1.8 to the fluidounce). Wine of antimony keeps far better than aqueous solutions of tartar emetic, but yet will deteriorate in time. From ten to thirty drops is the average dose. Wine of antimony is an ingredient of the *compound mixture of glycyrrhiza* of the Pharmacopœia. (See *Glycyrrhiza*.)

Tartar emetic enters into the composition of the official compound syrup of squill. (See *Squill*.)

Tartar emetic, as a soluble antimonial, possesses local properties wanting in the insoluble compounds hitherto discussed. It is, namely, powerfully irritant, and applied to the skin in ointment or plaster produces after a while an eruption, papular at first, but passing to vesicles or pustules, much resembling the eruption of smallpox, for which it actually has been mistaken. The eruption is painful, and may leave scars. Pustulation by tartar emetic is a possible, but disagreeable method of effecting a continuous counter-irritation. The best mode of application is to prescribe an ointment of one part of tartar emetic to four of simple ointment, to be rubbed, but rubbed lightly, into the skin. Too vigorous inunction may produce an uncontrollable inflammation.

3. General Therapeutics of Antimony Compounds.—*Vascular Depression*.—The power of antimonials to reduce the pulse is unbounded, but in high degree the effect is associated with so much general depression as to be unavailable. Still, in the beginning of a congestion or inflammation, notably of the air passages, in a vigorous subject, a mild antimonial effect is often most happy. Indeed, so marked often is the benefit, that it is probable that depression of undue vascular excitement is but one factor of the curative influence.

Promotion of Secretion in Catarrhs.—Nauseants generally tend to this effect, but none can compete with antimonials in power. Yet again, the use of antimonials should be confined, except in very small dosage, to the fairly vigorous, and particularly should be avoided in subjects at either extreme of age.

Induction of Vomiting.—Although a powerful, antimony is a poor emetic, since it is both slow and unnecessarily nauseant and depressing. Furthermore, the vomiting does not stop when the stomach is empty, as is the case, practically, with the so-called mechanical emetics. For these reasons the emetic operation of antimony is nowadays rarely utilized.

Relaxation of Spasm.—In full antimonial nausea the concomitant muscular debility may determine relaxation of spasm, as in *laryngismus stridulus*, or may be pronounced enough to be of avail in the reduction of a hernia or dislocation. But for all these purposes an even greater degree of paresis is so easily obtainable by medicines less disagreeable and depressing than anti-

monials that the latter are seldom resorted to for the therapeusis. Tartar emetic, in full dosage, has been praised highly by some in the treatment of tetanus.

Edward Curtis.

ANTIMONY, POISONING BY.—Pure metallic antimony is not thought to be directly poisonous. Symptoms of gastro-enteritis occasionally followed its medicinal use in times past, and serious symptoms are said to have been produced by the metal when inhaled in the state of vapor; but the effects in these cases have usually been attributed either to the partial oxidation of the metal or to the presence of arsenic, which is a frequent impurity in commercial antimony. Many of the compounds of antimony are more or less poisonous. The most important of these are tartar emetic and the terchloride of antimony.

TARTAR EMETIC.—This is a double tartrate of antimony and potassium, and is the most important compound of antimony. It occurs in the form of colorless, slightly efflorescent, crystals, which are usually rhombic octahedrons, or in the form of a white powder obtained by the pulverization of these crystals. It is soluble in about fifteen parts of water at the ordinary temperature, and in less than three parts of boiling water. Tartar emetic may give rise to acute poisoning, as a result of a single large dose, or to chronic poisoning, as a result of small doses frequently administered. Its poisonous properties are due to the oxide of antimony which it contains.

Acute Poisoning, Symptoms.—When a large dose of tartar emetic is taken, the acrid metallic taste of the poison is usually perceived by the patient. After a short time, varying from a few minutes to half an hour, there is nausea and faintness, followed by violent vomiting. There is burning in the throat and œsophagus; sometimes great thirst and difficulty of swallowing, pain in the stomach and abdomen. The vomiting is usually persistent. The vomited matters consist at first of the contents of the stomach, then of mucus, later of mucus mixed with bile, and in some cases blood. Violent and persistent purging is usually an early symptom. The discharges are liquid, resembling those of cholera, and frequently contain blood. Symptoms of extreme depression and prostration, ending in collapse, which is a prominent feature in acute tartar-emetic poisoning, soon appear. The skin is cold and covered with perspiration; the pulse, which appears to be increased in frequency till immediately before vomiting sets in, is at this stage diminished in frequency and force, and may become imperceptible; the respiration is irregular, but for the most part slow, with hasty and forced inspiration and prolonged expiration; the temperature is lowered. Cramps in the extremities, delirium, loss of consciousness, and convulsions, not infrequently precede death. The urine in mild cases is increased in quantity, as it is also in the beginning, even in fatal cases; but in such, toward the close, it is generally scanty and bloody, and even suppressed (H. C. Wood, Jr.). Exceptionally, vomiting is absent; in such cases the other symptoms are said to be, as a rule, more prominent. In some cases a pustular eruption, resembling that produced by the external application of tartar emetic, has appeared on the body on the third, fourth, or fifth day. In fatal cases death may occur within a few hours, but is more frequently delayed for two, three, or more days. Recovery is very frequent.

External Application.—Tartar emetic is occasionally employed externally as a counter-irritant, producing sooner or later a burning pain, followed by a pustular eruption, on the parts to which it has been applied. Its use for this purpose has been followed, in several instances, by symptoms of irritant poisoning as a result of its absorption through the integument. In two cases, at least, death has been caused by its application to the broken skin.

Chronic Poisoning, Symptoms.—The symptoms produced by the repeated administration of small doses of tartar emetic are of the same general character as those which have been described under acute poisoning. They are, however, less severe and less rapid in their progress, varying in these respects with the quantity administered and the frequency of the administration. The most prominent are nausea, retching, vomiting of mucous and bilious matters, soreness and constriction of the throat, a sensation of burning and pain in the stomach, a feeling of uneasiness and sometimes pain in the abdomen, a constant feeling of depression, gradual loss of strength, and progressive emaciation. The nausea and vomiting recur after each administration of the poison. Purging is not so prominent a symptom as in acute poisoning. The stools are at first normal; later, there may be diarrhœa, usually alternating with constipation. The time at which death occurs depends chiefly upon the size of the doses and the frequency of their administration. Taylor collected five cases, four of which were fatal. In three, death took place in six, eight, and nine days respectively; in the fourth, the poison was administered over a period of three months preceding death.

Fatal Quantity.—The quantity of tartar emetic required to destroy life cannot be stated with accuracy, since its effects are variable and frequently depend less on the quantity taken than on other conditions. Owing probably to early and abundant vomiting, recovery has frequently taken place after doses varying from 7.8 to 31 gm. (ʒ ij. to viij.). On the other hand, as a result probably of idiosyncrasy, alarming symptoms, and even death, have followed the administration of doses which would ordinarily be considered non-fatal. In sixteen fatal cases collected by Taylor, the smallest fatal dose was, in a child, 0.048 gm. (gr. 0.75), and in an adult, 0.130 gm. (gr. ij.); but in the latter case there were circumstances which favored the fatal operation of the poison. Taylor quotes a case in which 0.022 gm. (gr. 0.33), given in divided doses to a child four years of age, produced alarming symptoms. Serious symptoms have followed the administration of 0.032 gm., 0.26 gm. and 0.40 gm. (gr. 0.5, 4, and 6¼ respectively) to adults. Dr. Draper reported a case, at a meeting of the Boston Society for Medical Observation, in 1880, in which 0.26 gm. (gr. iv.), followed in ten minutes by 0.13 gm., proved fatal to a healthy adult woman in fifty-three hours. According to Wakley, 0.195 gm. (gr. iij.) killed an adult in twenty-four hours; 0.65 gm. (gr. x.) and 0.97 gm. (gr. xv.) have proved fatal to children; 2.3 gm. (gr. xxxvi.), 2.4 gm. (gr. xxxvij.), 3.24 gm. (gr. l.), and 3.9 gm. (gr. lx.) to adults. Children, aged persons, and those who are in delicate health are more susceptible to its action than healthy adults. On the other hand, there are certain diseased states of the body in which large and repeated doses have been administered without producing any symptoms of poisoning. Taylor concludes that under favorable circumstances 0.65 to 1.3 gm. (gr. x. to xx.), taken at once, might destroy an adult, and that a still smaller quantity than this might suffice if taken in divided doses.

Appearances.—The mucous membrane of the stomach and intestines is usually more or less inflamed and softened. The inflammatory appearances in the intestines are usually most marked in the duodenum, cæcum, and rectum. The mucous membrane of the mouth, throat, and œsophagus is sometimes inflamed. There are occasionally aphthæ and pustules in the mouth, throat, œsophagus, or stomach; sometimes aphthous ulceration of the glands of the small intestines. The stomach and intestines contain more or less mucus, colored with bile or blood or both. Hypostatic congestion of the lungs has been frequently noticed. A greater or less degree of fatty degeneration of the liver, kidneys, heart, muscular tissue of the diaphragm, and cells of the gastric glands, sometimes recognizable only by microscopic and chemical examination, is a well-recognized result of the action of antimony compounds. This was first pointed out by Saikowsky, who states that there is also a diminution of the amount of glycogen in the liver, and in some cases a total disappearance of it.

Absorption and Elimination.—Antimony is quickly absorbed, and after death may be detected in nearly all the organs and tissues of the body. It is rare to find more than a trace in the stomach, since its emetic properties usually secure its early removal. The liver and kidneys probably contain the largest amount. It is eliminated in the urine and bile, also, according to Lewald, in the milk. When tartar emetic is injected into the veins it is said to be rapidly eliminated through the mucous membrane of the stomach (Brinton). The time required for its complete elimination is uncertain. Millon and Laveran detected antimony in the urine of patients as late as twenty-four days after the last administration of tartar emetic. They also found antimony in the fat, bones, and other tissues of dogs, as late as four months after the last administration. They state that there are well-marked intermissions in the elimination.

Treatment.—If vomiting has not occurred, it should be provoked by tickling the throat or by the administration of warm water. The best antidote is tannic acid, which forms with oxide of antimony a compound insoluble in water. A solution of the acid may be used. In the absence of this, an infusion of green tea, decoctions of oak bark, gall nuts, or Peruvian bark, or tincture of kino or catechu, all of which contain tannic acid, may be administered. The stomach should be thoroughly washed out after the administration of the tannic acid. Opium should then be given, to allay pain and irritation. Stimulants, external and internal, may be required. In the treatment of chronic poisoning it is essential to prevent the further administration of the poison. Stimulants, tonics, and nutritious diet are required.

Terchloride of Antimony, Butter of Antimony,—This is a transparent, fusible, crystalline substance, which, on exposure to moist air, rapidly deliquesces to a clear liquid. When pure it is colorless, but it frequently contains more or less chloride of iron, which imparts to it a color varying from yellow to dark brown. It is decomposed by water, with the formation of hydrochloric acid and an insoluble white basic chloride, which may be distinguished from the corresponding basic chloride of bismuth by its solubility in tartaric acid. A concentrated hydrochloric acid solution of the chloride has some uses, and has given rise to a few cases of accidental or suicidal poisoning. It is a violent corrosive and irritant.

Symptoms.—These resemble closely the symptoms produced by the mineral acids. They come on very rapidly, and consist of violent vomiting and severe pain in the throat, stomach, and abdomen, soon followed by symptoms of collapse. Death has taken place in two hours, and has been delayed for ten and one half, eighteen, and twenty-four hours.

Fatal Quantity.—The smallest quantity required to destroy life is unknown. Ninety cubic centimetres (three fluidounces), approximately, of the solution has proved fatal to adults in three cases. Recovery has taken place after 30 c.c.

Appearances.—The lips, mouth, and throat have usually been found more or less corroded. The interior of the stomach and upper part of the small intestines are intensely inflamed, corroded, and sometimes black, as if charred. In a case related by Taylor, the whole alimentary canal, from the mouth to the middle of the small intestines, presented this black appearance. The mucous membrane was entirely destroyed, and the parts beneath were so soft that they were easily torn with the fingers. Fatty degeneration of the liver, kidneys, heart, muscular tissue of the diaphragm, and cells of the gastric glands, was observed in rabbits to which small doses of terchloride of antimony were administered (Saikowsky).

Treatment.—This consists in the administration of sodic carbonate, chalk, or magnesia, to neutralize the free acid, and of preparations containing tannic acid.

William B. Hills.

ANTINERVIN is a proprietary remedy, which, according to Squibb, contains acetanilid 50 parts, ammonium bromide 25 parts, and salicylic acid 25 parts. It is antipyretic and sedative in eight-grain doses.

W. A. Bastedo.

ANTIPERIODICS.—The various malarial fevers are all characterized by a more or less regular recurrence of their characteristic symptoms, to wit: chill, fever, and sweating; the periods for such recurrence varying according to the life cycle of the particular organism which causes the special type of fever. These phenomena are therefore spoken of as periodical, and the remedies which are known to exert an inhibitive effect upon them are called antiperiodics. The symptoms against which antiperiodics are most commonly employed are those constituting the seizure in the estivo-autumnal, tertian, and quartan types of ague, and consisting of the cold, the hot, and the sweating stages. In the milder forms of intermittent and remittent fever, the breaking up of the recurrent chills as soon as possible is important for the comfort of the patient, but in the so-called "pernicious" malarial fevers, it may be a matter of life or death to stop at once those congestive chills whose effects are so alarming, and it is in such cases that the great value of the antiperiodics is seen. Other chronic manifestations of the malarial cachexia, such as neuralgia, are amenable to antiperiodic treatment, and it is noticeable that the success of quinine in the relief of neuralgia is in proportion to the regular periodicity of the attacks.

By far the most important antiperiodic—of more value, in fact, than all the others taken together—is cinchona, with its derivatives. Ever since the cure of the Countess of Cinchon of an ague at Lima, in the earlier half of the seventeenth century, first gave name and fame to the drug, its value in intermittent fever has been acknowledged. More than any other remedy in the Pharmacopœia it deserves to be considered a specific. Its direct action on the malarial parasite in the blood has been abundantly shown.

Quinine, by reason of its more concentrated and convenient form, is now used almost entirely to the exclusion of cinchona as an antiperiodic. For this purpose the dose must be large, corresponding in quantity to the so-called antipyretic dose of the drug. The quinine should be so administered as to produce a saturation of the patient's system at the time when the next seizure would occur. To attain this object we may best give one full dose, 1 to 2 gm. (gr. xv. to xxx.) on the drop of temperature following a given paroxysm in order to abort the following paroxysm. Or it may be given in divided doses through the twenty-four hours before an expected chill, the last dose being six hours before the time the chill is due. If the interval is much shorter than this, the chance of aborting the very next seizure is diminished. If a single administration of the drug anticipates the chill by only four or five hours, the chances are about equal for and against its success. In no other form is quinine more effective than in that of the crystals of the sulphate in an acid solution (bisulphate) or dissolved in lemon juice. The solubility is usually somewhat impaired in the pill form, and the administration in coffee fails to give the best effect because of the imperfect solubility of the tannate. The manufacturing chemists have put upon the market a "compound syrup of licorice," which quite effectually disguises the bitter taste of the drug, without, so far as the writer knows, interfering with its solubility.

When the periodicity of the intermittent fever is irregular, and in cases of remittent fever, cinchonism should be produced as soon as possible after a seizure, and maintained by moderate but sufficient doses for several days. In the cases of pernicious malaria, if there are not ten or twelve hours before the expected time of attack in which to secure complete cinchonism by the oral administration of the drug, it should be given subcutaneously. In order to secure its complete solution, acid must be added, one minim of dilute sulphuric acid to each grain of quinine usually sufficing. But this solution has the disadvantage of being irritating, and

there is some danger of abscess. This risk, however, should be taken in preference to that of a severe congestive chill. The hydrobromate of quinine is especially adapted for subcutaneous use. It may be prepared according to the following formula:

℞ Quininæ sulph.................. 10 (gr. clx.)
  Acidi hydrobromici (Squibb)... 4 (ʒ i.)
  Aquæ (vel spts. frumenti)...ad 30 (ad ℥ i.)

The kinate and the disulphate of quinine are preferred by some for hypodermic use. The dose of quinine subcutaneously is less than by the mouth, and its action is more prompt. When for any reason neither of the foregoing methods is available, the drug may be given by the rectum in doses somewhat larger than by the mouth. For children and others with sensitive stomachs, when haste is not an especial object, quinine may be given by inunction. For this purpose an eligible preparation is the following:

℞ Quininæ sulph................. 5 (gr. lxxx.)
  Acid. oleic. pur............... 30 (℥ i.)
  Ol. olivarum.................. 30 (℥ i.)

Dissolve the quinine in the acid with the aid of gentle heat. Add the oil. The solution should be clear.

There is considerable choice among the various salts of quinine both as to their strength and as to their solubility. For example, the acetate contains 87 per cent. of quinine, the basic and neutral hydrochlorate each nearly 82 per cent., the basic lactate 78, the basic hydrobromate 76, the basic sulphate 74, the neutral sulphate less than 60 per cent., while the tannate, much in favor for administration to children in the form of "chocolate quinine tablets," has only 20 per cent.

The hydrochlorate is the most soluble salt, and as it is one of the richest in quinine, it is, in spite of its slightly greater cost than some others, the most eligible. The neutral hydrobromate is soluble in 6 parts of water, while the basic sulphate is soluble only in 581 parts of water.

In old malarial cases, in many of which the liver is enlarged, we must, in order to get the full and prompt effect of quinine, preface or accompany its exhibition by the use of a mercurial, as calomel or blue pill, followed by a saline.

The other alkaloids of cinchona, quinidine, chinoidine, cinchonidine, and cinchonine, have some antiperiodic value, but are all inferior to quinine, and if used should be given in larger doses. Regarding the dose of quinine, it should be said that it varies much not only with the individual, but with the place. In the tropics and in the habitat of malaria much larger doses are tolerated and are necessary to break up a chill than in temperate climates and non-miasmatic localities. The prophylactic value of quinine against ague is even greater than its curative action. A moderate amount—as, for instance, a grain three times a day—may be taken constantly for years without any ill effects. This precaution is one that should be taken by every one compelled to live in a malarious country. Even in non-malarious districts persons who have contracted ague elsewhere should, after breaking up the chills by the antiperiodic doses, as described above, continue with small quantities of quinine for a fortnight or more, or better, with a full dose once a week.

Next to cinchona, the most useful antiperiodic which we possess is probably arsenic. It is to those chronic cases which have assumed a somewhat irregular type, and in which we hardly know at what time to expect a chill, that arsenic is particularly adapted. It may be given in the form of Fowler's solution, beginning with 0.3 gm. (♏v.) three times a day, thence carried up to 0.5 or 0.7, or even 1 gm. three times a day, or the arsenious acid may be given in granules of at first 0.0015 to 0.002 gm. (gr. $\frac{1}{40}$ to $\frac{1}{30}$) three times a day, pushed till the physiological effects are reached. With arsenic we do not attempt to stop the very next paroxysm; hence it is not adapted for pernicious cases. It should always be well diluted and given on a full stomach.

When treatment has been delayed until the chill is actually "on," quinine is useless for that seizure. Nothing is so efficacious to check a chill actually in progress as a full dose of morphine subcutaneously. Chloroform is also recommended for this purpose in a dose of from 2 to 4 gm. (ʒ ss. to i.) in sweetened water or mucilage. Good effects have been claimed for the administration, during the chill, of nitrite of amyl by inhalation, and nitrate or muriate of pilocarpine hypodermically.

Nectandra, or bebeeru bark, has met with some success as an antiperiodic. The alkaloid, in the form of the sulphate of beberine, contains whatever of virtue the drug possesses, and may be given in the same doses and at the same times as quinine.

Warburg's Tincture, formerly in much repute, especially in India, as an antiperiodic, contains some sixty-four ingredients, of which the most active is quinine, in the proportion of ten grains to the ounce.

The eucalyptus seems to possess some antiperiodic virtue. Among the peasantry of Southern Europe it has quite a reputation. Careful observation shows that in highly malarious localities it is often without effect. The oil of eucalyptus in doses of 0.1 to 0.3 gm. (♏ij. to v.), may be given, or the tincture in doses of 1 to 2 gm. (♏xv. to xxx.). That it is of use in the milder cases is made probable by the fact of its undoubted power as a prophylactic. Since the tree was introduced into Southern Europe in 1856, its growth has much improved the healthfulness of many marshy regions. The Trappist monks devoted themselves to cultivating this tree in the most malarious regions of Italy, with the result of making places habitable that were formerly highly unhealthy.

Among the other succedanea of quinine, usually most successful when combined with, rather than entirely replacing, that drug, are salicin and salicylic acid, given in doses of 1.0 to 1.3 gm. (gr. xv. to xx.), repeated frequently until tinnitus is induced; the antipyretics of the coal-tar series, antipyrine, phenacetin, etc. The sulphites, especially the sulphite of magnesia and the hyposulphite of soda, have been recommended by some physicians in this country, in doses of 1.0 to 1.5 gm. every two hours. The ferrocyanide of iron, despite its disagreeable appearance and taste, has been found useful by Flint in doses of 4 to 8 gm. (ʒi. to ij.). Nitric acid in 0.5 gm. (♏ vij.) doses, every six hours, through paroxysm and intermission; the chloride of sodium, given to the extent of 10 gm. (ʒij.) during the intermission; the chloride of ammonium, the iodide of ammonium, and the iodide of potassium, in 0.3 to 0.5 gm. (gr. v. to viij.) doses, repeated and increased; piperine and narcotine, each in doses of 0.2 gm. (gr. iij.); methylene blue (gr. ij. to iv.) in capsules—these and other drugs have all had their advocates as being of more or less value in preventing the periodic attacks of ague.

Finally, it remains to allude to two or three classes of drugs under which most of the other numberless remedies that have been suggested against intermittent fever may be classed. Emetics and cathartics, when there is time for their administration, sometimes render the system more susceptible to the action of quinine. Alum, ipecac, sulphate of copper, fraxinus, wahoo, Indian hemp, and the like probably owe what reputation they have as antiperiodics to this fact; administered alone they would be quite worthless. Some of the simple and aromatic bitters, on the other hand, may, in mild cases, replace cinchona. Anthemis (chamomile); eupatorium (thoroughwort), ilex (holly), parthenium (feverfew), hydrastis, and cascarilla have a popular repute in the treatment of intermittent fever, by reason of their bitter quality. When it is remembered that the natural tendency of ague is to recovery as soon as the subject is removed from the source of malarial infection, the antiperiodic value of a large number of the drugs last enumerated will appear quite problematical.

Charles F. Withington.

ANTIPYRETICS. See *Appendix, Vol. VIII.*

ANTIPYRIN. — "PHENAZONE," "ANALGESIN," $C_6H_5(CH_3)_2C_3HN_2O$. This popular antipyretic was made known to the profession by Ludwig Knorr in 1884. It is a coal-tar derivative prepared according to a patented process, by the action of acetyl acetic ether upon phenyl-hydrazine, the patent for which expired in 1899. It is a base somewhat analogous to ammonia, and has the property of combining with an acid or an alkali to form salts. It is official in the B. P. under the title *Phenazone.*

It occurs in colorless, scaly crystals, without odor and possessed of a somewhat bitter taste. It is readily soluble in water, alcohol, and chloroform, less so in ether, about one part in fifty. The melting point is 110° C. Ignited with free access of air it burns without residue. It is neutral to test paper.

Antipyrin may be distinguished from all other organic compounds by the action of ferric chloride; this producing a deep red color which is discharged by the addition of dilute sulphuric acid in excess. Other compounds produce various colors and differ in the effect of the sulphuric acid. The bright red color is clearly visible in 1 to 100 solution; in 1 to 100,000 a light brown, and in 1 to 500,000 a light yellow color is produced. Nitrous acid added to a solution forms a green color, and nitric acid a yellow color which deepens to crimson on warming. Both these tests are characteristic of antipyrin. The presence of acetanilid is also detected by the melting point of the suspected salt. The two compounds melt approximately at the same temperature, but a mixture of the two reduces the melting point very decidedly, equal parts melting at 45° C. Many other distinctive tests have been proposed. In 1 to 1,000 solutions, iodine and iodide of potassium produce a reddish-brown, potassio-mercuric iodide a white, and potassio-bismuthic iodide an orange-red precipitate. In 1 to 100 acidulated solutions, Nessler's reagent, mercuric or auric chloride, and tannic acid, produce colorless or yellow precipitates; picric acid a yellow; and ferrocyanide of potassium a bluish-green precipitate.

The solubility of antipyrin and its action as an alkaloidal base render many drugs and preparations incompatible, and not infrequently some very unsightly as well as inert mixtures are ordered by the physician. E. J. Millard and A. C. Stark [1] describe a series of experiments made for the purpose of testing the compatibility of antipyrin with the whole of the drugs and preparations of the pharmacopœia that are likely to be prescribed in combination, together with many that are unofficial. The following is the list they have prepared and the changes that are produced:

Acid. carbolic.: precipitate.
Acid. hydrocyan. dil.: yellow coloration.
Acid. nitric. dil.: faint yellow coloration.
Acid. tannic.: white insoluble precipitate.
Alumen (ammonia): deep yellow coloration and precipitate.
Amyl nitrite (acid): green coloration.
Arsen. iodid.: precipitate.
Chloral hydras: precipitates in strong solution, no apparent action in dilute.
Cupri sulphas: solution turns green.
Dec. cinchonæ: precipitate.
Ext. cinchon. liq.: precipitate.
Ferri sulph.: brownish-yellow color and precipitate.
Glycer. ac. carbol.: precipitate.
Glycer. ac. tannic.: precipitate.
Hydrarg. perchl.: precipitate.
Infus. catechu conc.: precipitate.
Infus. cinchon. acid.: precipitate.
Infus. rosæ acid.: precipitate.
Infus. uvæ ursi: precipitate.
Liq. arsen. et hyd. iod.: precipitate.
Liq ferri perchlor.: }
Liq. ferri pernit.: } blood-red coloration.
Liq. ferri persulph.: }
Liq. pot. permang.: reduction quickly takes place.
Sodii salicylas: liquefies.
Spts. ætheris nit. (acid): green coloration.
Syr. ferri iodid.: reddish-brown coloration.
Tinc. catechu: precipitate.
Tinc. cinchonæ: precipitate.
Tinc. cinchon. co.: precipitate.
Tinc. ferri perchl.: red coloration.
Tinc. gallæ: precipitate.
Tinc. hamamelid.: precipitate.
Tinc. iodi: precipitate.
Tinc. kino: precipitate.
Tinc. laricis: precipitate.
Tinc. rhei: precipitate.

It was found that with dilute acids no change took place, as with sulphuric, hydrochloric, nitric, and phosphoric acids, soluble salts were formed. The changes that take place with amyl nitrite and nitrous ether occur only when the preparations are acid and contain free nitrous acid, but as this is generally present under ordinary circumstances, these compounds should never be prescribed with antipyrin. Calomel is considered to form a toxic compound when combined with antipyrin, but these observers were unable to notice any change, and mercuric chloride could not be detected in the mixture. Sodium bicarbonate, when triturated with antipyrin, causes a decomposition and disengages the odor of ether. Many substances combine with antipyrin to form stable and definite chemical compounds. Some of them have proved to possess important therapeutic properties and their number is constantly being increased. The most important of these are iodopyrin, salipyrin, and hypnal, information in regard to which may be sought for under their respective titles. The following have also been recommended:

Naphthopyrin is formed when antipyrin is triturated for a length of time with beta-naphthol, one part of the latter with two parts of the former. It assumes the character of a tough mass which gradually forms into crystals when kept for a length of time. It is insoluble in water, soluble in alcohol and ether. A more recent method of preparing the drug is by dissolving 150 gm. of naphthol in ninety per cent. alcohol, and adding to it gradually 190 gm. of antipyrin dissolved in the smallest possible quantity of water. The mixture is to be constantly stirred, and in a few minutes it becomes clouded and then clear; the pure crystals being deposited.

Antipyrin benzoate is formed by the addition of antipyrin to a boiling aqueous solution of benzoic acid. It is slightly soluble in cold and boiling water, but very soluble in alcohol and ether. It has a pungent taste and a slight odor of benzoic acid. A *citrate* and *picrate* may be prepared in the same way.

Phenopyrin is prepared by mixing equal parts of crystalline phenol and antipyrin. It forms an oily liquid, free from color, insoluble in cold and sparingly soluble in hot water.

Pyrogallopyrin is obtained by the interaction of pyrogallol and antipyrin in substance or in solutions. It is a crystalline substance, sparingly soluble in hot or cold water, but soluble in alcohol and ether.

Resopyrin results from the interaction of solution of resorcin and antipyrin; an oily mass is formed which solidifies into a hard, white, opaque body. From an alcoholic solution it forms in crystals. It is not soluble in water, but is so in alcohol, ether, and chloroform.

The physiological effect of antipyrin has received more attention than many of the later derivatives of the same character, and in this country the work of Wood, Reichert, Hare, and Cerna and Carter has done much to advance our knowledge of this remedy. Upon the nervous system the action is similar to that of other antipyretics. There is a short stage of stimulation followed by one of depression. Upon the motor tracts it acts by dulling the power of conducting impressions and inhibits reflex action.

Upon the sensory nerves, antipyrin acts as an anodyne both when administered internally and when locally applied. This effect is early manifested, and before any

dangerous stage begins it has been shown that animals can be operated upon without causing them pain. The muscular sense is also lost early, the signs of ataxia being among the first symptoms noticed and the last to pass off; the special senses are at first rendered more sensitive, but this is quickly overcome and depression follows.

The antipyretic properties are considered due to the action of the drug on the heat centres rather than to any influence upon the circulation. It has been shown that it causes a diminution in the production of heat, and continues to act when the secretion of the skin is checked by a previous dose of atropine.

Antipyrin exerts a very decided action upon the respiration. Even in small doses it has been known to greatly accelerate the number of respirations, and in all cases in which toxic doses are given the rapidity is excessive, and, as a fatal termination approaches, the expirations become spasmodic in character. This has been shown not to be influenced by the section of the vagus nerves, and is assumed to be due to a direct action on the respiratory centre in the medulla oblongata.

In moderate doses very little effect is produced on the circulation, but in large doses it weakens the heart and causes depression and collapse. As the result of experimental work, Drs. Cerna and Carter[2] formulate the following conclusions, which, in general, coincide with the work of previous observers: 1. In small and moderate amounts antipyrin produces a rise of the arterial pressure, this stimulating effect being due to an action on the heart. 2. A lowering of the pressure by large and toxic doses is due similarly to a depressant action of the drug upon the cardiac organ. The remedy does not appear to affect the vasomotor system. 3. Antipyrin causes an increase in the pulse rate through paralysis of the cardio-inhibitory centres. The secondary decrease in the number of pulsations is of a purely cardiac origin, the drug exercising a depressant effect upon the heart itself.

Upon the blood there is no effect when moderate doses are administered: in large quantities, however, it produces a chocolate discoloration of the blood which is due to the alteration of the hæmoglobin into methæmoglobin. There is no alteration of the corpuscles caused by the drug itself, but ultimately its administration may lead to a diminution in number and may produce anæmia.

In many instances antipyrin exerts an irritant action on the stomach and causes nausea and vomiting. Another objection to its employment is the copious perspiration which is frequently produced and which generally accompanies a rapid reduction of temperature. A rash of the character of urticaria, in some cases described as resembling measles and scarlatina, is caused in some patients. It generally follows the use of the drug for a length of time, but in many instances a single small dose has had this effect. These rashes are usually accompanied by a burning and itchiness of the skin, and are exceedingly distressing. They rarely continue for more than a few hours and no ill effects remain, but in some cases vesicles, bullæ, and hemorrhagic rashes have been reported, the effects of which persist for some time. Another condition which proves very annoying is an irritation of the mucous membrane of the nose and throat, which may end in an ulcerative stomatitis.

The toxic symptoms produced when the drug has been given in very large doses are convulsive in character, and in accord with the symptoms observed in experimental research upon animals. There are generally marked salivation and lachrymation very quickly following the dose, crying and other signs of distress, and in a short time ataxia. This is followed by a convulsive stage, during which spontaneous convulsions are frequent, and are easily caused by flashes of light, clapping of hands, etc. Subsequently there will be paralysis, insensibility, and death. Respiration and the heart are greatly hurried, and death occurs during a convulsion or from paralysis of respiration. The heart generally continues to beat for some time, and is finally arrested in diastole.[3] When the drug is administered in lesser quantities, and often in ordinary doses, very unfavorable symptoms occur, the result of a depressant action. Collapse of the most alarming character sometimes follows ten and fifteen grain doses, and this is often accompanied by cyanosis and swelling of the eyelids and extremities. The milder symptoms of a toxic action are a rapid and weakened heart, shallow respiration, dyspnœa, oppression in the chest and in the head, giddiness, vertigo, numbness of the surface, irritation of the mucous membranes and skin, and many other symptoms indicating a depression of the circulation and nervous system. This undesirable action is the one great drawback of what is undoubtedly the most efficient antipyretic and analgesic compound that has yet been produced. To this is to be ascribed its decreased employment, as the frequent onset of alarming symptoms, often as sudden as they are unexpected, has caused the profession to avoid its employment in many cases in which it undoubtedly would prove of service. A careful consideration of cases in which the drug has been given will generally enable one to avoid these dangers. That dangerous symptoms are not very common is shown by the result of a collective investigation of the British Medical Association. Of one hundred and sixty-nine observers who reported, no fewer than one hundred and thirty-eight had never observed any ill effects worth mentioning. It is advised to exercise caution in cases of cardiac debility and whenever the respiratory organs or kidneys are affected. The remedy must also be cautiously given to the aged.

Antipyrin is rapidly absorbed, its effects are quickly produced, its elimination from the system begins within a short time after administration, and it is entirely removed within a few hours. In children it has been noticed that there is apparently a tolerance of the drug, as very large doses may be given without producing ill effects. In order to ascertain whether this was or was not due to a rapid elimination of the drug, a series of very interesting observations[4] were made. The urine of children, adults, and aged, to whom eight grains were administered, was systematically examined to determine the first appearance of the drug and the length of time it continued to be excreted. It was found that in the case of all the subjects excretion began within fifty minutes, and that within an hour the drug was present in abundance. The excretion, however, was most rapid in the children, in whom it could not be detected after fifteen or twenty hours; whereas in the adults it was present for twenty-four or thirty hours, and in the case of the aged its excretion was still more slow. When the dose was increased it was found that its first appearance in the urine was not hastened, but its elimination was much prolonged. It is also eliminated by the other secretions, including the milk of nursing mothers.

When antipyrin was introduced as an antipyretic the dose recommended was thirty grains in a single dose, which was to be repeated in four hours if the pyrexia was present, and a third dose of fifteen grains was to be given in another four hours if there were any signs of a rising temperature. This medication produced a decided reduction in the fever, and maintained a condition of apyrexia for from twenty-four to forty-eight hours; it was, unfortunately, often accompanied by profuse sweating and other signs of collapse, and was soon abandoned. It is now given in doses of from ten to fifteen grains, which may be repeated at short intervals if no effect is produced. When it is administered for the first time, it is safer to begin with five-grain doses. The fall of temperature generally begins in from half an hour to one hour, and the lowered temperature is maintained for several hours. In some instances the fall is very rapid, a decline from 103 to 96 F. taking place. Sometimes it is necessary to repeat the dose very frequently before any effect is produced, it apparently being necessary to saturate the system before freedom from fever is secured. In typhoid fever, and in all febrile disorders in which there is a periodic rise and fall of temperature, the time of its administration should be observed, as its action is much more marked when it coincides with the decline of the fever. In typhoid fever it is rarely employed as a mode

of treatment by the continuous administration of the drug; it is considered only of value as a means of reducing hyperpyrexia. Its use in tuberculous troubles is not looked upon with much favor, one great objection being the perspiration that is caused. It has been suggested to combine atropine with it as a means of counteracting this effect. In rheumatic fever it has been advocated by many as a remedy superior to the salicylates; in these cases it is given in fifteen or twenty grain doses five or six times a day. In many instances it has secured relief from pain when salicylate of soda has failed, but it has not proved itself equal to the older remedy in the treatment of rheumatism in any form when accompanied by fever.

Although introduced as an antipyretic, antipyrin was soon found to possess very decided analgesic and anodyne properties, and the latter application of the drug has almost eclipsed its earlier use. In all forms of pain of a neurotic origin, or in nervous diseases accompanied by pain, it has proved itself of especial value. It has been used with success in neuralgia, migraine, pruritus, sciatica, and lumbago, in the pains of tabes dorsalis, in the pains of angina, and in those arising from aneurism. It has been found to replace morphine in renal colic and asthma, and has even proved itself to be superior, as it in no way deranges the secretions. It has been used in all conditions in which the hypodermic use of morphine is generally resorted to, and has been found a very efficient substitute in the greater number of cases. As a remedy for headaches of a nervous origin it is very beneficial. In the forms peculiar to growing children, and in those accompanying anæmia and debility, it has been recommended by Germain Sée, who employed it in a large number of cases with marked success. The same observer also considers it of value in pain of a rheumatic character unaccompanied by fever. Although inferior to the salicylates in the febrile forms, he considers it decidedly superior to all other drugs when there is no fever. In the pains of dysmenorrhœa and other pelvic disorders it has also been employed with success. Its use in such cases is indicated when the suffering is of a nervous character, as the drug exerts no influence on the uterine contractions and fails to relieve the pains that arise from the efforts of the uterus to expel its contents. In obstetrical practice it has allayed much of the suffering that accompanies labor. Its effect resembles that of chloral. In the first stage, in primiparæ and in neurotic patients, it lessens the rigidity of the os and allays the painful spasmodic action. In tedious labor it lessens the exaggerated nervous pain which often in a reflex manner interferes with the efficiency of the uterine contractions. It is useless for the pain of the second stage, which is mechanical in its character. For the after-pains, due to the expulsion of clots, it is without effect, but in those that are of a neuralgic character it affords marked relief. The employment of the drug does not in any way increase the tendency to post-partum hemorrhage. It exercises no ecbolic action, and has proved of service in allaying the pains and checking the progress of threatened abortion. It has been recommended in cases in which it is desired to reduce the secretion of milk. Cases are reported in which doses of eight grains lessened the amount within a day and checked it altogether in three days.

The action of antipyrin on the spinal cord and nerve centres has led to its employment in many diseases of a neurotic character. In chorea it has proved useful, both in cases traceable to rheumatism and in those in which there was no such history. In a report [5] of sixty cases in which it was used, it was found to benefit two-thirds, diminishing the severity of the attack and shortening its duration. Recurrence, however, was noticed in three-fifths of the cases. It was found necessary to give large doses, from 3 to 6 gm. daily being required. This was found to be well tolerated for several weeks, and serious symptoms of poisoning were never noticed. Antipyrin was suggested as a remedy for whooping-cough by Sonnenberger, in 1887, and it has been used for this purpose to a very great extent, with varying results. The dose should be from two grains upward, according to the age of the child. One grain and a half for each year has been advised; for infants of a few months of age one-half to three-quarters of a grain is sufficient. In many of the cases reported remarkable effects have been announced, the disease having been cut short in a few days. This drug has also proved of service for enuresis, when of nervous origin and due to irritability of the bladder. It has also been employed in epilepsy, but not with encouraging results, but more favorable results are reported from its combination with ammonium bromide. From time to time cases have been reported of diabetes that have been successfully treated with antipyrin. The quantity given has ranged from 2 to 6 gm. daily. In some instances the excretion of sugar was wholly checked; in the majority it was lessened in quantity and the patient was relieved of all troublesome symptoms. The most marked effects were noticed in nervous patients and when the polyuria was excessive. The diet must not be neglected.

Antipyrin possesses a decided antiseptic action, and it has been suggested that this should be utilized both by internal administration and as a local application. It has been shown that a two-and-one-half-per-cent. solution prevents the development of the bacillus of diphtheria in various cultures, and a five-per-cent. solution applied to a culture containing the bacillus destroyed it in twenty-four hours. It has also been found to exert a powerful neutralizing action on the toxins of diphtheria. Applications of the remedy to the throat and its internal administration are advocated in this disease, but satisfactory evidences of the beneficial effects of this treatment are still lacking.

In stomachic disorders and diarrhœas of children antipyrin has been employed on account of its effect in checking fermentation. It is given in doses ranging from one-half to one or two grains.

The local application of the drug has proved of decided value as an anæsthetic remedy in various troubles of the nose, throat, and larynx; a solution of the strength of about four per cent., used as a spray or painted directly on the mucous membrane, being found effective in allaying the congestion and lessening the sensibility and irritability of the part. It at first causes a sense of heat and smarting, but this rapidly passes away and is followed by ease and comfort, and freedom from all the painful sensations that may have accompanied the inflamed condition. The sensitiveness of the nasal mucous membrane is more marked than that of the pharynx, and an application of cocaine is often required before the antipyrin can be applied; in such cases it is advisable to begin with a one-per-cent. solution. The powdered drug, or concentrated solutions, have been found to exert an anæsthetic and very astringent action, and have been used for the treatment of tuberculous disease and other painful affections, and in conditions in which there is a reflex element present. When it is applied in these concentrated solutions the resulting anæsthesia is complete, and lasts for one or two hours. A ten-per-cent. solution in a one-per-cent. solution of carbolic acid has been advised in operations upon the urethra.

Antipyrin has also been used in the treatment of certain forms of eye disease. Weak solutions of from one to three per cent. have been used with advantage in simple acute or chronic conjunctivitis. Under the influence of three or four washings a day, the secretion diminishes and a cure is rapidly effected. The solution at first causes a sensation of burning, which may be painful, but this lasts only a few moments and is followed by relief from all distress. Antipyrin [6] has recently been used to replace jequirity in the treatment of scrofulous pannus which has resisted other methods. The eye is to be rendered anæsthetic with cocaine, and a thin layer of antipyrin is deposited on the cornea with a brush, or by means of an insufflator. In spite of the cocaine the patient complains of pain and burning, and there is more or less lachrymation. When this reaction subsides the eyeball is gently massaged through the closed lid. The inflammation that arises varies in intensity, and from one

to several days must elapse before the process is repeated. The contraindications to this treatment are the presence of corneal ulcerations and phlyctenular keratitis. The most suitable cases are those in which there is extensive proliferation of the blood-vessels.

A very important property of antipyrin is its power of controlling hemorrhage. When placed in contact with blood at its normal temperature it thickens and condenses it without causing coagulation. When a concentrated solution or the powdered drug is applied to a mucous membrane it causes an anæmia more or less marked, according to the strength of the solution. When applied to an animal's mesentery the blood grows darker in color, the circulation becomes slow and ultimately ceases, and the parts appear almost bloodless after the application of a fifty-per-cent. solution. This styptic action may be secured by applying a plug of cotton saturated with a fifty-per-cent. solution to the bleeding surface, or the powdered drug may be used. This action has been confirmed in numerous cases of epistaxis and of bleeding from the tonsils, or after the extraction of teeth, and even in cases of uterine hemorrhage. In many instances it has been found that a ten-per-cent. solution was sufficient in ordinary hemorrhage from mucous membranes. In hæmoptysis of phthisis its internal administration was thought to prove beneficial, but the large quantities required to produce this effect were accompanied by dangerous symptoms.

To secure the full benefit of antipyrin it requires to be given in doses of ten to fifteen grains, and these should be repeated until the desired effect is obtained, or until forty or fifty grains have been given. These large doses have been given for a prolonged period without any ill effects, and to children much greater quantities in comparison have been given. The drug is generally administered in solution, and it is considered advisable to combine it with alcohol, ammonia, or some diffusible stimulant. The hypodermic injections have been advocated when it is desired to secure a local anodyne action. The effect is noticed in ten or fifteen minutes, and it lasts for six or eight hours. The usual dose is about four grains in ten minims of water, and when the painful area is great a number of injections are required. Cocaine often has to be added, as much pain is sometimes experienced. This method of administering the drug is not without its dangers, as it has produced gangrene of the toes when injected for painful affections of the foot. When the stomach is irritable and rebels against antipyrin, or when a local action on the pelvic organs is wished for, it may be given as an enema: antipyrin, gr. x. to xx., tinct. opii, ♏v., aquæ, ℥iv. It may also be prepared as a suppository where such can be used with convenience.

Beaumont Small.

[1] The Druggists' Circular, August, 1890.
[2] Notes on New Remedies, 1892.
[3] Johns Hopkins' Bulletin, April, 1890.
[4] British Medical Journal, July 11, 1891.
[5] British Medical Journal, January 17, 1891.
[6] Therapeutic Gazette, December, 1892.

ANTIRHEUMATICUM (Kamm) occurs in the form of blue prismatic crystals which result from the action of sodium salicylate on methylene blue. It is soluble in water and alcohol, and is used in doses of gr. i. to gr. v., three times a day, in acute articular and gonorrhœal rheumatism. Larger doses tend to irritate the kidneys.

W. A. Bastedo.

ANTISEPSINE.—Asepsine, para-brom-acetanilid, para-mono-brom-phenyl-acetamide ($C_6H_4Br.NH.CH_3Co$). Prepared by acting with bromine on a solution of acetanilid in glacial acetic acid. The resulting white precipitate is recrystallized from alcohol. Antisepsine occurs in colorless crystals slightly soluble in water and somewhat more so in alcohol. It is antipyretic, antineuralgic, and analgesic, its action being much like that of acetanilid, but with a tendency to be more sedative. Dose, gr. ij. to x.

W. A. Bastedo.

ANTISEPTICS.—Those agents only which have the power of preventing the putrefactive decomposition of organic material are properly called *antiseptics* (from ἀντί, against, and σηπτικός, putrefying). But inasmuch as these agents have also the power of arresting other forms of fermentation due to the action of micro-organisms of the same class—*e.g.*, the acetic fermentation, the alkaline fermentation of urine, etc.—it will not be necessary to consider antizymotics—a more comprehensive term—separately, and we may accept as satisfactory evidence of antiseptic power the ability of a chemical substance to prevent the development of bacteria of any kind in a medium suitable for their growth. The amount of a given antiseptic agent necessary to accomplish this result is not, however, the same for all species of bacteria, but varies considerably, and can be ascertained for each species only by carefully conducted experiments.

Putrefactive decomposition is a complex process due to the combined or successive action of a variety of micro-organisms, and attended with the formation of a large number of volatile and non-volatile products. The volatile products of putrefaction, many of which are known to us only by their offensive odors, are those which, being recognized by the sense of smell, enable us to distinguish *septic* from other forms of fermentation. An agent which destroys these bad-smelling products of putrefaction is a *deodorant*. It is a popular error to suppose that an *antiseptic* or a disinfectant—terms which are often confounded—is an agent which neutralizes these putrefactive odors.

It is true that an antiseptic or a disinfectant may destroy the volatile products of putrefaction. Many agents properly so called have this power; they are not, however, properly so called for this reason. An antiseptic prevents the development of such volatile products by virtue of its power to arrest the process—putrefactive fermentation—which gives rise to them. (For definition of *disinfectant*, see article under that heading.) So, too, as regards the non-volatile products of putrefaction. Some of these are highly poisonous substances which it may be desirable to destroy, and they may be destroyed by certain of the chemical agents recognized as antiseptics; but this power does not entitle such agents to be ranked as antiseptics any more than does the power to destroy the volatile products of putrefaction. We know, as a result of extended experiments, that those agents which restrain the development of septic organisms also restrain the development of known disease germs, and *vice versa*. We are therefore justified in speaking of those agents as antiseptics which have been proved by laboratory experiments to prevent the development of pathogenic organisms in suitable culture media. Great care, however, must be exercised in drawing any inferences from experiments made upon one organism with reference to the *amount* which may be necessary to prevent the development of another. Thus the bichloride of mercury prevents the development of anthrax spores when present in a culture fluid in the proportion of 1 to 300,000; whereas some micrococci, and certain bacilli, commonly present in putrefying infusions, can multiply in the presence of 1 to 40,000.

It is evident that an agent which has the power of destroying putrefactive organisms must be an antiseptic. *Germicides* (see this heading) are, therefore, antiseptics. But antiseptics are not necessarily germicides, and, as a matter of fact, some of the best-known and most extensively used antiseptics have no germicide power at all, or else destroy the vitality of micro-organisms of this class—bacteria—only when used in a concentrated solution and after a comparatively long exposure; *e.g.*, alcohol, common salt, borax, etc.

Certain chemical agents are antiseptics because of their power in very small amounts to precipitate albuminous matters from organic infusions, and thus to render such infusions unsuitable as pabulum for the development of low organisms. This is especially true of the sulphate of iron, sulphate of zinc, chloride of zinc, and other metallic salts which are extensively used as "disinfectants." It is difficult to determine whether these substances also

exert a restraining influence upon the development of germs, inasmuch as their action upon the organic pabulum essential for such development is manifested almost immediately, when they are added in very dilute solution to a culture medium. It is probable, however, that those agents which have been shown to possess germicide power—as, for example, the chloride of zinc, which destroys the bacteria of putrefaction in the proportion of one part to fifty—exert a restraining influence upon the development of bacterial organisms in amounts somewhat less than are required for the destruction of vitality. This inference is based upon our knowledge of the antiseptic action of other germicides which do not destroy our culture media by causing a precipitation of albuminoid matters contained in them.

Certain substances, which in dilute solution have no restraining power upon the development of low organisms, or may even serve as pabulum for them, in a concentrated solution prevent putrefactive decomposition; *e.g.*, sugar, chloride of sodium, sulphate of magnesia, etc. It is probable that these substances, in concentrated solution, prevent the development of putrefactive organisms by giving a density to the fluid containing them, which is incompatible with the performance of physiological processes—osmotic?—upon which vital activity depends.

After this brief account of the *modus operandi* of antiseptics we proceed to consider the comparative value of these agents as established by experimental data.

And first we may refer to certain antiseptics extensively employed in the preservation of food products, the use of which is so general and widely known that a mere mention of them is all that will be required in the present place. The list includes sugar, used largely in the preservation of fruits; vinegar, employed for the preservation of certain vegetables; alcohol, used to preserve fruits, and, very extensively, for the preservation of anatomical, pathological, and natural history specimens; and chloride of sodium, our main reliance for the preservation of meats and fish. All of these commend themselves for use by reason of their cheapness and the absence of noxious properties, rather than because of their antiseptic power, which is comparatively low. Every pathologist knows that his specimens are liable to spoil if the alcohol in which they are kept is not of the strength of fifty per cent. or above, and every merchant knows that his "pickled" pork or fish will become putrid in warm weather if the brine in which they are kept is not very "strong."

Attempts to establish the exact antiseptic value of various chemical agents have been made by numerous investigators, but it is hardly worth while to consider any experimental data published prior to 1875, as the methods adopted prior to that time were not such as could give reliable results, and we have more recent data concerning extended researches which conform more nearly with the exactions of science, upon which we shall base our detailed account of the comparative value of antiseptics.

In conformity with the broad sense in which the term antiseptics is used in the present article we shall report facts relating to the power of the agents named in restraining the development of pathogenic micro-organisms, or of those concerned in various fermentations, as well as those relating to their power to prevent putrefactive decomposition, to which a more strict use of the term would limit us.

In attempting to compare the results of different authors it will be necessary to remember that conformity can be expected only in those cases in which the same test organism has been employed, and in which the conditions, as to the nature of the culture fluid, etc., have been identical.

When the antiseptic agent is volatile it is evident that the result, in a protracted test, will be influenced by the form of the receptacle and the fact of its being open to the air or hermetically closed, as in the culture flasks used by the writer. Again, when the conditions of the experiment are such that the "breaking down" of a flask of beef tea, containing a certain antiseptic in a given amount, as in the experiments of Miquel, depends upon the development of spores or desiccated organisms contained in "dust," or upon accidental inoculation by air-borne spores, the material will be preserved for a longer time than in experiments in which a drop or more of fluid swarming with bacteria is added to the solution at the outset. And the larger the quantity of material containing putrefactive bacteria which is added to a culture fluid protected by an antiseptic the greater will be its liability to "break down."

In giving a detailed account of the comparative value of antiseptics we shall follow the classification of Miquel,[1] to whom we are indebted for a very comprehensive and carefully conducted series of experiments made at the Observatory of Montsouris, Paris, in connection with his extended researches relating to atmospheric organisms. The figures given in the following tables also represent the results reported by this author, unless otherwise stated.

The classification of Miquel is as follows:

	Effective in the proportion of	
1. Substances eminently antiseptic....	1 : 100,000	to 1 : 10,000
2. Substances very strongly antiseptic.	1 : 10,000	to 1 : 1,000
3. Substances strongly antiseptic......	1 : 1,000	to 1 : 200
4. Substances moderately antiseptic...	1 : 200	to 1 : 50
5. Substances feebly antiseptic........	1 : 50	to 1 : 10
6. Substances very feebly antiseptic...	1 : 10	to 1 : 3.33

In the experiments of Miquel, the amount of each agent tested—in grams—which was required to prevent the putrefaction of one litre of beef tea was determined, thus giving directly the ratio per 1,000. When an agent failed in the proportion of 300 gm. to the litre it was dropped from the list; for, as Miquel says: "In quantities greater than this a substance can scarcely be called an antiseptic, inasmuch as all substances known to chemists, including some of the most fermentable, will preserve indefinitely one litre of bouillon when present in a larger amount than this."

Miquel recognizes the importance of experiments to determine the restraining power of chemical agents upon various species of bacteria, separately, and especially upon "disease germs," but he says: "As to me, faithful to a plan adopted at the outset, I will treat the subject in a more general manner by making known simply the minimum weight of the substances capable of preventing the evolution of any bacteria or germs.

"The method adopted is very simple. To a liquid always comparable to itself it is sufficient at first to add a known weight of the antiseptic and some atmospheric germs or adult bacteria, and to vary the quantity of the antiseptic until the amount is ascertained which will preserve indefinitely the liquid from putrefaction. In order to obtain germs of all kinds in the dry state it suffices to take them, where they are most abundant, in the dust collected in the interior of houses or of hospitals, and to procure a variety of adult bacteria we may take the water of sewers."

In the writer's experiments, published in *The American Journal of the Medical Sciences* (April, 1883), a different plan was adopted, inasmuch as the object in view was to ascertain the restraining influence of various antiseptics upon several different micro-organisms—isolated in pure cultures—for the purpose of determining whether different species of bacteria have widely different vital resisting power to the action of these agents, or whether results obtained with a single test organism could be applied to other organisms of the same class. These experiments, which are included in Table No. IV. of my paper referred to, taken in connection with those of Koch on anthrax spores, those of Arloing, Cornevin, and Thomas on the virus of symptomatic anthrax, those of Salmon on the micrococcus of fowl cholera, etc., show that there are marked differences in the ability of organisms of this class to multiply in the presence of certain antiseptic agents. These differences depend mainly, however, upon the fact that spores are unable to germinate in the presence of very small amounts of certain agents, such, for example, as the bichloride of mercury; and that micrococci and

bacilli in process of active growth may develop in the presence of very much larger amounts of these agents.

In the writer's experiments the antiseptic agent, in a given proportion, was added to a culture fluid; this was then introduced into little culture flasks of the form shown in the figure.* The capillary extremity of the flask was then hermetically sealed in the flame of an alcohol lamp, and the contents of the flask sterilized by long boiling in a water bath. Having now a sterilized culture fluid containing the antiseptic to be tested in known proportion, it is only necessary to introduce into the flask a minute drop of fluid from a similar flask, containing a "pure culture" of the test organism, in order to ascertain the restraining power of the agent under trial with reference to this particular organism. By multiplying the experiments we gradually approach the limit and establish the minimum quantity of each agent required to prevent the development of the several test organisms.

FIG. 219.

The experiments of De la Croix[2] were made by a method which does not differ essentially from that adopted by Miquel.

1. SUBSTANCES EMINENTLY ANTISEPTIC.

This list, according to the researches of Miquel, embraces:

	Efficient in the proportion of
Mercuric iodide	1 to 40,000
Silver iodide	1 to 33,000
Hydrogen peroxide	1 to 20,000
Mercuric chloride	1 to 14,300
Silver nitrate	1 to 12,500

Of the substances included in this list, the bichloride of mercury (mercuric chloride) is that which has heretofore received the greatest attention, and by reason of its comparative cheapness (it can be bought by the thousand pounds for fifty cents per pound), its solubility, etc., it recommends itself at once as an antiseptic of great practical value.

The figures given by Miquel represent the proportion in which this agent will permanently prevent the development of any of the widely distributed micro-organisms in dust deposited from the atmosphere. In the writer's experiments, which have recently been repeated with similar results, it was found that 0.003 per cent., or 1 part in 33,000, prevented the development of the test organisms employed, while one-half this amount failed—1 to 66,000. These results are not in conflict with those of Miquel, in which the test included a great variety of organisms. In my own experiments I encountered a minute bacillus, associated with other putrefactive organisms, which multiplies in solutions containing 1 to 20,000, but the restraining power of the antiseptic is shown in this proportion by the fact that multiplication is delayed, and does not occur during the first twenty-four hours to such an extent as to interfere with the transparency of the culture solution, and it was only after remaining from forty-eight to seventy-two hours in the culture oven, at 38° C., that the fluid became clouded and was found to swarm with this minute actively moving bacillus. On the other hand, the development of the spores of certain bacilli was prevented by a much smaller proportion. Thus I am able to verify the statement of Koch as to the astonishing power of this agent to prevent the development of anthrax spores. A decided restraining power is shown when it is present in the proportion of 1 to 600,000, inasmuch as in a sterilized culture medium containing this amount, anthrax spores produce only a few flocculi of filaments at the end of forty-eight hours, while in the same medium, without the bichloride, an abundant and luxuriant development occurs in less than twenty-four hours.

In one experiment, in which anthrax spores were introduced into two culture flasks containing 1 to 100,000, two containing 1 to 200,000, and two containing 1 to 400,000, no development occurred during the first twenty-four hours in any of the flasks, while an abundant development had taken place in another flask containing the same culture medium, without any bichloride, which was inoculated at the same time to test the purity of my stock solution. At the end of forty-eight hours a feeble development of anthrax bacilli had taken place in the two tubes containing 1 to 400,000, while the others still remained clear.

According to De la Croix, the development of bacteria in beef tea is prevented by 1 to 10,250. This is something more than the amount fixed by Miquel, but it must be remembered that these results are all only approximate, and the statement that 1 to 10,250 prevents development is not to be interpreted as meaning that 1 to 14,300 will not. No intermediate experiment may have been made, for example, between 1 to 10,250 and 1 to 20,500 (referring to De la Croix's experiments). Thus in the writer's experiments, published in *The American Journal of the Medical Sciences*, the standard solution was commonly diluted one-half after each experiment; and, starting with one per cent., we have the following series in experimenting with this agent: 0.1 per cent., 0.05 per cent., 0.025 per cent., 0.012 per cent., 0.006 per cent., 0.003 per cent., 0.0015 per cent.—in which failure occurred only when the proportion was reduced to .0015 per cent., equal to 1 to 33,333; which proportion may be stated in round numbers, on the safe side, as 1 to 30,000 in the case of the micrococci of pus. Recent experiments made by the same method, and with the same test organism, have fixed the limit between 1 to 30,000 and 1 to 40,000. The field is open for those who desire greater exactness to make the experiments for themselves.

To the list of substances "eminently antiseptic" we must add *formaldehyde* gas, or an aqueous solution of this gas—it is also an excellent deodorant and powerful germicide. In the experiments of Slater and Rideal[7] formaldehyde in the proportion of 1 to 20,000 was found to inhibit the development of most bacteria, but Staphylococcus pyogenes aureus developed in the presence of 1 to 5,000. Walter[8] found that 1 to 10,000 absolutely prevents the development of anthrax spores, of the typhoid bacillus, of the diphtheria bacillus, and of Staphylococcus pyogenes aureus.

2. SUBSTANCES VERY STRONGLY ANTISEPTIC.

In this table we have:

	Efficient in the proportion of
Osmic acid	1 to 6,666
Aluminum acetate (De la Croix)	1 to 6,310
Aluminum acetate (Kuhn)	1 to 5,250
Chromic acid	1 to 5,000
Chlorine	1 to 4,000
Iodine	1 to 4,000
Chloride of gold	1 to 4,000
Bichloride of platinum	1 to 3,333
Oil of mustard (De la Croix)	1 to 3,353
Hydrocyanic acid	1 to 2,500
Picric acid (De la Croix)	1 to 2,005
Bromine	1 to 1,666
Cupric chloride	1 to 1,428
Thymol	1 to 1,340
Cupric sulphate	1 to 1,111
Salicylic acid	1 to 1,000

We notice first in this group the haloid elements, chlorine and iodine, which by the experiments of Miquel are given the same value—1 to 4,000. This is exactly the value obtained for iodine in my experiments heretofore referred to, in which three different test organisms were used. According to Buchholz,[3] 1 to 5,714 of iodine pre-

*"To introduce a culture liquid into one of these little flasks, heat the bulb slightly, break off the sealed extremity of the tube, and plunge it beneath the surface of the liquid. The quantity which enters will, of course, depend upon the heat employed, and the consequent rarefaction of the enclosed air. Ordinarily the bulb is filled to about one-third of its capacity with the culture liquid, leaving it two-thirds full of air, for the use of the microscopic plants which are to be cultivated in it."—From the writer's work, "Bacteria," Wm. Wood & Co., New York.

vents the development of bacteria in tobacco infusion. De la Croix fixes the antiseptic power of this agent at 1 to 2,010 for boiled beef infusion, and 1 to 10,020 for unboiled. This would indicate that the nature of the culture medium employed largely influences the result. In the case of agents which destroy organic matter by oxidation, or which cause the precipitation of albuminoid materials held in solution in our culture fluids, this must evidently be the case. It is therefore necessary that experiments shall have been made upon organisms contained in culture media of identical composition, in order that the experiments of one observer may be compared with those of another. And in protracted experiments with chlorine and other gaseous or volatile substances we must take into account the possibility of loss when the receptacle containing the culture fluid is not tightly closed. Differences of this nature in the conditions may perhaps account for the wide discrepancy of the results by Miquel and by De la Croix with reference to *chlorine*.

The last-named author gives the antiseptic value of this agent in *unboiled* beef infusion at 1 to 15,606, while Miquel gives it at 1 to 4,000. My own experiments with *chlorine* relate only to its power as a disinfectant. (See article under this title.)

A discrepancy also exists between the results of Miquel and of De la Croix as regards the antiseptic power of *bromine;* the former author places it at 1 to 1,666, the latter at 1 to 5,597.

Again, we have a discrepancy as regards the action of *chloroform*, one author (Miquel) placing it at 1 to 1,250, and the other at 1 to 103.

Oil of mustard, which is said by De la Croix to prevent the development of micro-organisms in unboiled beef infusion, has been shown by Koch to be capable of preventing the development of anthrax spores in the proportion of 1 to 33,000. According to the same author the *oil of turpentine* destroys the spores of anthrax in five days, and retards their development in the proportion of 1 to 75,000.

Thymol retards the development of these spores in still more dilute solutions—1 to 80,000 (Koch). Buchholz has determined the antiseptic power of this agent in Pasteur's fluid as 1 to 2,000, a result which does not differ greatly from that given by De la Croix for unboiled beef infusion —1 to 1,340.

Sulphate of copper is practically one of the most important agents which appear in this group, and the results of Miquel are in conformity with those of Dougall[4] in giving it a high place as an antiseptic. It is quite extensively used in France, and there can be no doubt of its value from this point of view; but it would be a great mistake to infer from this that it is a reliable disinfectant. (See article under this heading.)

3. Substances Strongly Antiseptic.

	Efficient in the proportion of
Benzoic acid	1 to 909
Potassium bichromate	1 to 909
Potassium cyanide	1 to 909
Muriate of quinine (Ceri)	1 to 900
Aluminum chloride	1 to 714
Ammonia	1 to 714
Zinc chloride	1 to 526
Mineral acids	1 to 500 to 1 to 333
Thymic acid	1 to 500
Lead chloride	1 to 500
Nitrate of cobalt	1 to 476
Sulphate of nickel	1 to 400
Nitrate of uranium	1 to 356
Carbolic acid	1 to 333
Potassium permanganate	1 to 285
Lead nitrate	1 to 277
Alum	1 to 222
Tannin	1 to 207

Benzoic acid is given a higher value by De la Croix than that given in the table, which is taken from Miquel. It is said to prevent the development of bacteria in unboiled meat infusion in the proportion of 1 to 1,439, and to fail in the proportion of 1 to 2,010. According to Koch, 1 to 2,000 retards the development of spores.

The antiseptic power of the salts of *quinine* has been especially studied by Ceri.[5] According to this author the development of bacteria in a culture fluid inoculated with a drop of turbid fluid from malarial soil is prevented by a solution of muriate of quinine of 1 to 1,900; from 1 to 1,000 to 1 to 15,000 non-putrid development begins. In experiments by the writer a minute bacillus associated with the bacteria of putrefaction developed in the presence of 1 to 800, but the results obtained were, in general, sufficiently in conformity with those reported by Ceri to give confidence in the data he has furnished. The power of this agent to restrain the multiplication of germs in the proportion of 1 part to 800 and above indicates that its therapeutic value may depend, in part at least, upon a restraining influence exercised upon the development of germs present in the alimentary canal, but our data scarcely justify the belief that in doses commonly administered it is competent to prevent the multiplication of pathogenic bacteria in the blood and tissues generally.

According to Dougall, the "salts of the alkaline earths" would occupy a comparatively subordinate position as antiseptics were it not for the extremely high preventive point of *aluminum chloride*, which is given at 1 to 2,000 for hay infusion. This is much beyond the value fixed by Miquel (1 to 714), but may be due to a difference in the culture medium used in the two series of experiments. Additional experiments with this agent and with aluminum acetate are desirable.

The antiseptic power of *chloroform* is fixed by De la Croix at a much lower figure than that given by Miquel, and is given at 1 to 103. Evidently experiments with this agent cannot be compared unless we know that loss by evaporation has been prevented in both cases.

Zinc Chloride.—The antiseptic power of this salt, which is fixed by Miquel at about 1 to 500, is no guide to its use as a disinfectant—for which purpose it is frequently recommended,—inasmuch as my experiments show that 1 part in 50 is required to destroy micrococci, and Koch has shown that anthrax spores are not destroyed by exposure for a month to a five-per-cent. solution.

The antiseptic power of the mineral acids is given by Miquel at from 2 to 3 gm. per litre (1 to 500 to 1 to 333). In the writer's experiments *sulphuric acid* prevented the development of all of the test organisms in the proportion of 1 to 800, and according to De la Croix 1 to 3,353 prevented the development of bacteria in unboiled beef infusion. The same author states that sulphurous acid prevents the development of bacteria in the same infusion in the proportion of 1 to 12,649.

Carbolic acid has received special attention from experimenters on account of its extended use, under the teaching of Lister, in surgical practice, and of the popular idea growing out of this, that it is the antiseptic *par excellence.*

Miquel, in his work published in 1883 (*op. cit.*), has given the antiseptic value of this agent as 3.20 gm. to the litre of *bouillon*. In a later report it is given as 3 gm. per litre (1 to 333). In the writer's experiments 1 to 500 was found to prevent the development of all the test organisms, and all of these organisms multiplied in the presence of 1 to 1,000. De la Croix also states that 1 to 502 prevents the development of bacteria in unboiled beef infusion.

According to Haberkorn[6] the multiplication of bacteria in urine is not prevented by 1 to 100, and Salmon states that the micrococcus of swine plague multiplies abundantly in urine containing 1 to 100. This would indicate that the restraining power of carbolic acid is neutralized by some ingredient in the urine. The germicide power of this agent is also influenced by the nature of the liquid in which it is in solution. Thus Koch states that in solution in oil or in alcohol in the proportion of five per cent. it fails to destroy anthrax spores in one hundred days or more. Anthrax bacilli are, however, destroyed by 1 to 100, while 1 to 850 prevents their development.

4. SUBSTANCES MODERATELY ANTISEPTIC.

	Efficient in the proportion of
Bromhydrate of quinine	1 to 182
Arsenious acid	1 to 166
Boric acid	1 to 143
Sulphate of strychnine	1 to 143
Arsenite of soda	1 to 111
Hydrate of chloral	1 to 107
Salicylate of soda	1 to 100
Ferrous sulphate	1 to 90
Caustic soda	1 to 56
Citric acid	?
Acetic acid	?

The antiseptic power of *boric acid* was fixed by Buchholz at 1 to 133, tobacco infusion being the fluid employed in his experiments. This corresponds very closely with the figures given by Miquel. But Kuhn states that it failed to preserve a solution of egg albumen in the proportion of 1 to 101. On the other hand, the writer's experiments gave more favorable results for all of the test organisms employed, and these differed considerably for the different organisms. Thus the micrococci of pus multiplied freely in the presence of 1 to 400, but failed to multiply in 1 to 200; the micrococcus of pneumonia did not multiply in the presence of 1 to 400. It will be noted that, according to Miquel, the antiseptic power of *salicylic acid* (1 to 1,000) is ten times that of salicylate of soda (1 to 100).

The antiseptic power of *ferrous sulphate* is placed by Miquel at 1 to 90. In the writer's experiments it was found to be efficient in the proportion of 1 to 200 for all the test organisms. It is but fair to state, however, that in these experiments the culture solutions were not left in the culture oven longer than forty-eight to seventy-two hours, and it is possible that some of them might have broken down at a later date if the time had been prolonged, for the antiseptic power of certain agents in dilute solutions is often shown by delayed development of micro-organisms subjected to their action, and after a time these organisms may develop freely in the same solution. Whether in this case the agent has been neutralized chemically, or whether the organisms, developing feebly at first, may after a time become habituated to it, is a question not yet definitely settled. The commercial sulphate of iron contains a certain amount of free sulphuric acid which adds to its antiseptic value. The writer's experiments were made with a chemically pure protosulphate, and no doubt Miquel also experimented with the pure salt. It must be remembered that the value of this and other metallic salts as antiseptics is no criterion for their use as disinfectants. In saturated solution the protosulphate of iron does not destroy the vitality of any of the test organisms experimented upon by the writer, and Arloing, Cornevin, and Thomas assert that a twenty-per-cent. solution did not destroy the virus of symptomatic anthrax after forty-eight hours' exposure.

The caustic alkalies—soda, lime, and potash—all have considerable value as antiseptics, but this has not been definitely determined. Their value as "germicides" will be given under that heading.

5. SUBSTANCES FEEBLY ANTISEPTIC.

	Efficient in the proportion of
Protochloride of manganese	1 to 40
Calcium chloride	1 to 25
Sodium borate	1 to 14
Muriate of morphine	1 to 13
Strontium chloride	1 to 12
Lithium chloride	1 to 11
Barium chloride	1 to 10
Alcohol	1 to 10

The writer's experiments give a much higher antiseptic value to *borax* than that reported by Miquel, viz., 1 to 200 for two species of micrococcus. De la Croix states that the development of bacteria in unboiled beef infusion is prevented by 1 to 107. But, as heretofore indicated, the *permanent* preservation of a culture fluid, exposed to the air, from all kinds of micro-organisms present in the atmosphere requires a larger amount of this and of other antiseptic agents than is necessary to restrain development for two or three days, when only a few micro-organisms of one of the species mentioned are introduced into a flask such as the writer used in his experiments. The differences in results are probably due, not to error, but to differences in the conditions of the experiments.

According to De la Croix, *alcohol* in the proportion of 1 to 20 prevents the development of bacteria in unboiled beef infusion. It is probable that the figures of Miquel are nearer the mark when the experiment is protracted, for pathologists are aware that their specimens are liable to spoil and to develop a putrefactive odor in solutions containing forty to fifty per cent. of alcohol.

6. SUBSTANCES VERY FEEBLY ANTISEPTIC.

	Efficient in the proportion of
Ammonium chloride	1 to 9
Potassium arsenite	1 to 8
Potassium iodide	1 to 7
Sodium chloride	1 to 6
Glycerin (sp. gr., 1.25)	1 to 4
Ammonium sulphate	1 to 4
Sodium hyposulphite	1 to 3

My experiments correspond with those of Miquel in giving to sodium hyposulphite a very low place in the list of antiseptics, and yet this salt has been extensively prescribed as an antizymotic agent. If it has any such powers as have been ascribed to it by Pollo and others, it must be in consequence of its undergoing decomposition in presence of certain substances with which it comes in contact in the alimentary canal. In this case the sulphurous acid, if set free, would no doubt act as a potent antiseptic and germicide. But the pure salt introduced into culture solutions failed entirely to exhibit any restraining power upon the development of the test organisms up to eight per cent., at which point it was dropped. From Miquel's experiments it appears that when present in more than thirty per cent. the development of micro-organisms in beef tea is prevented. But in this proportion it is probable that any soluble salt would preserve a culture solution by giving it a density incompatible with the development of micro-organisms.

George M. Sternberg.

[1] M. P. Miquel, M.D., Chef du service micrographique à l'Observatoire de Montsouris: Les organismes vivants de l'atmosphère, chap. ix., pp. 289-299, Paris, 1883; also article in the Annuaire de météorologie for 1884.

[2] N. Jalan de la Croix: Das Verhalten der Bakterien des Fleischwassers gegen einige Antiseptica. Arch. f. exper. Path. u. Pharmakol., Leipzig, 1880-81, xiii., 175-225.

[3] Antiseptica und Bakterien. Arch. f. exper. Path. u. Phàrmakol., iv., 1-81, 1875.

[4] Medical Times and Gazette, London, April 27, 1872.

[5] L'action de la quinine en rapport avec le dévelopement des germes et des organismes inférieurs. Trans. Internat. Med. Cong., London, 1881, i., 466-472.

[6] Das Verhalten von Harnbacterien gegen einige Antiseptica, Dorpat, 1879, 8vo.

[7] London Lancet, vol. i., 1894, p. 1004.

[8] Zeitschr. für Hygiene, xxi., 421, 1896.

ANTISEPTOL is the trade name for a substance prepared by mixing a solution of 25 parts of cinchonine sulphate in 2,000 parts of water, with a solution of 10 parts each of iodine and potassium iodide in 1,000 parts of water. The precipitate formed is washed and dried and constitutes a reddish or dark brown powder, without odor, almost insoluble in water and freely soluble in alcohol and chloroform. It is an odorless iodoform substitute containing fifty per cent. of iodine, and when used internally is given in dose of gr. i. to v. Antiseptol is also known as cinchonine iodogallate and cinchonine herapathite, although its chemical formula is unknown.

W. A. Bastedo.

ANTISPASMIN is a double salt of sodium salicylate and narceine-sodium, having the formula $C_{23}H_{26}NO_8Na+3C_6H_4OHCOONa$. It is a reddish, slightly hygroscopic powder, which is readily soluble in water; fifty per cent.

of it consists of narceine. As an antispasmodic and sedative it is given in whooping-cough, laryngismus stridulus, chorea, asthma, etc., especially in children, and is useful in allaying irritating cough or intestinal colic in adults. On account of its affinity for moisture it is preserved with difficulty in the dry state, and therefore may well be kept in five-per-cent. solution; of this, five to eight drops are given to a child of six months, or forty drops to a child of five years; an adult may take one or two drachms.

W. A. Bastedo.

ANTISPASMODICS.—If we are to interpret the term antispasmodic in its literal sense as a means of preventing spasm, nothing so completely fills the requirement as ether or chloroform, pushed to complete anæsthesia. In conducting a careful physical examination, especially in diseases of the abdomen or pelvis, such relaxation of spasm is often secured by anæsthetizing the patient. But as ordinarily used by therapeutists the word antispasmodic is given a somewhat loose and unscientific application to a class of drugs supposed to be of special service in controlling attacks of muscular spasm depending upon functional nervous derangement. The inappropriateness of the name is seen from the fact that it is not alone convulsive phenomena which form indications for their use, but that they are also useful in other of the multiform manifestations of nervousness or of hysteria. The theory of their mode of action—if, indeed, any one method of action is common to all the members usually included in the class—is not sufficiently established to make any discussion of it profitable in this place. Suffice it to say that it is not impossible that at least one important action of these drugs is a local one upon the intestinal tract, where their warming and stimulating character may produce a revulsive effect. For the detailed description of the most important drugs included under this heading the reader is referred to their proper titles.

Belladonna has a considerable power of relaxing spasm, as, for instance, in the unstriped muscular tissue of the intestine. It and its congeners, stramonium and hyoscyamus, are also much used in asthma, which is a disease attended by spasm of the bronchi. In the same condition opium is at times of the greatest value, the hypodermic injection of morphine alone causing relief to some asthmatic attacks. In "colic" (meaning spasm of the muscular walls of the intestine) opium is also invaluable. This drug, like the anæsthetics already mentioned, while distinctly antispasmodic, has other and more important therapeutic qualities which lead to its classification in another group (see *Anodynes*), and we pass to those remedies known more specifically as antispasmodics. First, we have a group of animal origin, strongly odorous, but of little therapeutic value. *Moschus*, musk, an oily substance obtained from the preputial glands of the Thibetan musk-deer, is the only one of this class which is used to any extent. In the last stages of adynamic diseases, as typhoid fever, it is given, especially by German physicians, but rather as a forlorn hope than with real confidence. Its former use in hysteria is now quite superseded. *Castoreum*, a corresponding secretion from the *Castor fiber*, or beaver; *ambergris*, a morbid product obtained from the sperm whale, and the source of the *oleum succini;* and the *oleum animale* of Dippel, a substance of disgusting origin and nature, obtained from "trying out" decomposing animal structures, deserve mention only as having been at some time used as antispasmodics.

Another group consists of drugs of generally feeble action, but occasionally useful in infantile hysteria and allied states. Among these are *humulus*, hops, and its derivative, *lupulin*. The former, applied locally in the form of poultices or embrocations, has possibly some virtue, and the latter is somewhat more active internally. *Lactucarium*, derived from the garden lettuce, is even more feeble than hops, but as some persons are made drowsy by eating lettuce, it is not impossible that lactucarium may have in certain cases a useful medicinal effect. The claims which have been made for *celery* as an antispasmodic and anticephalalgic do not seem to rest on reliable grounds. *Cimicifuga*, or black snakeroot, belongs in this group. It has been chiefly used in chorea, and in full doses it has seemed to have some effect. *Dracontium*, the root of the "skunk cabbage," and *Galbanum*, an ingredient with asafœtida and myrrh in the *Pilula Galbani Comp.*, U. S. P., 1880, have also had antispasmodic virtues ascribed to them, but with little reason.

We now come to the group which contains the most important drugs of this class. They are three in number, viz.: *camphor*, *valerian*, and *asafœtida*. They all produce a sensation of warmth in the stomach, and probably stimulate the whole alimentary canal. But that this is not their sole action is proved by their superiority in certain nervous states over the essential oils and other so-called carminatives. The intestinal action of camphor makes that drug a valuable aid in the treatment of cholera and choleraic diarrhœa. In the delirium of adynamic fevers and as a sedative for "nervousness" it is useful. An especially quieting influence has been claimed for it in sexual irritation and excitement. For more distinctively hysterical symptoms, camphor is often combined with bromine in the form of bromated or monobromated camphor, which, despite its disagreeable taste, difficult solubility, and frequent tendency to cause irritation of the stomach, is considerably used for chorea, reflex convulsions, etc. Perhaps no drug is more generally used to combat the true hysterical convulsive seizure than *valerian*, and certainly in many cases it meets the indication better than almost any other agent. The fluid extract and the ammoniated tincture are among the most eligible palliatives of the hysteric attacks, sometimes a single dose serving to restore consciousness. For more protracted use in the countless nervous manifestations of hysteria, hypochondria, and neurasthenia, the salts of valerianic acid, notably the valerianates of zinc and of ammonium, are especially adapted, serving to control at times even such positive and conspicuous symptoms as neuralgia.

Asafœtida, long the synonym for what is most loathsome and offensive to the palate, acts very like valerian in the hysteric attack. The flatus which has been rolling about in the intestine is expelled, and, as has been intimated above, there is some reason to believe that the stimulation of the intestinal mucous membrane and the revulsion so caused may, with the relief of the tympanites, play a prominent part in the alleviation of the hysterical spasm. In cases in which simulation seems to have any part in the attack, the vile taste of the drug may become of service in adding to its effectiveness. In other cases we may give the drug by enema, and its action upon the intestine and also its effect on the convulsions will be nearly the same as if it were administered by the mouth.

While the above-mentioned drugs constitute the more distinctive antispasmodics, there yet remain two groups to which the term is often applied, and of which some part of the action is similar to that above described. The *compound spirit of ether*, Hoffman's anodyne, is very useful in controlling nervous disturbances, as is also the *spirit of chloroform*, formerly known as chloric ether. The substances from which these are derived—sulphuric ether and chloroform—may, administered internally in appropriate doses, be employed for the same purpose, although, of course, their more proper classification is among the anæsthetics. The *bromides* of *potassium*, *ammonium*, and *sodium* and chloral, though in their most prominent action depresso-motors, are yet, in moderate doses, used as antispasmodics.

Finally, we have the group which includes coffee, tea, maté, and guarana, of all which the active principle is practically identical with caffeine. Leaving out of account the important action of this substance upon the heart and circulatory system, and limiting our attention entirely to functional nervous phenomena, we find that in migraine, which in the family of diseases is not distant

of kin from hysteria, some of the most useful remedies are caffeine and guarana.

The newer analgesics of the coal-tar series, such as antipyrin, phenacetin, antifebrin, ammonol, antikamnia, etc., are of some service, though there is reason to fear that as "domestic remedies" they are employed to an extent which is not devoid of danger.

Charles F. Withington.

ANTISUDORIFICS; ANHYDROTICS.—These are a group of remedies employed to check excessive secretion from the sudoriferous glands. It includes belladonna and allied plants, agaricin, picrotoxin, sulphuric and phosphoric acids, sulphate of copper, oxide of zinc, and many other drugs which possess astringent properties. What may be termed indirect antisudorifics are strychnine, iron, and tonics generally, which act by improving the tone of the system and overcoming any debility which is often the predisposing cause.

A too free secretion from the skin is often an accompaniment of general debility, and is readily checked by appropriate treatment. That form which is of importance to the practitioner is the very profuse sweating met with in phthisis and in all forms of septic absorption. In these conditions the loss of fluid is at times enormous, and as there is also present a large amount of solids, it becomes a very exhaustive drain upon the system. This secretion is not an ordinary transudation of water in the form of serum. It is a special secretion controlled by special nerves, and any depression or paralysis of these nerves at once lessens the secretion. This is well seen in the effect of poisonous doses of belladonna, when the vaso-motors are paralyzed and the flow of blood in the skin is increased, but notwithstanding this the skin remains dry on account of the sudoriferous glands being also paralyzed.

The most valuable of antisudorific drugs is belladonna and its alkaloid. One of its earliest effects is to paralyze the secreting glands of the skin and mucous membranes, and, aside from its interfering to a slight extent with the digestion, its action is wholly favorable. The local application of the liniment or ointment will produce the same effect, and this treatment is often adopted in sweating hands and feet. If applied freely, absorption takes place, and its constitutional effects are produced. The local application to the chest has been employed, with benefit, in the "night sweat" of lung disease. The effect of belladonna is now almost entirely secured by the administration of atropine by the mouth, or preferably by hypodermic injection. It may be commenced in moderate doses of gr. $\frac{1}{120}$, but it will generally be found necessary to inject gr. $\frac{1}{75}$ or $\frac{1}{50}$ to obtain its proper action. Too frequently the dose employed is insufficient. Children require a larger dose, gr. $\frac{1}{60}$ or even larger quantities being given. The rapidity of its action varies; sometimes the system responds almost immediately, at other times its effect is not evident for three or four hours. Usually the effect of a full dose will last for two or three days.

When necessary to give opium, belladonna will prove a valuable combination to prevent the sweating which often arises during the use of that drug.

Hyoscymus and its alkaloids have also the same action. Agaricin has been used with much success in doses of gr. $\frac{1}{60}$ to $\frac{1}{4}$. Picrotoxin has also been recommended in doses of gr. $\frac{1}{100}$ to $\frac{1}{60}$. Zinc oxide, gr. ij. to iv. at bedtime, and sulphate of copper, gr. $\frac{1}{4}$, are very old remedies. One of the oldest remedies, and, next to belladonna, one that is the most generally employed, is the aromatic sulphuric acid. This requires to be given more continuously until it produces its astringent action. At first, ♏ xx. three or four times a day, should be given for two or three days, after which a single dose at bedtime will continue the effects of the day. The dilute phosphoric acid is also of service when administered in the same way. These acid astringents have not the same specific action as belladonna, but are probably excreted in part by the sweat glands, and during the excretion exercise their astringent action. Sulphate of copper and oxide of zinc probably, in addition, exert some effect upon the centres controlling secretion.

In septic diseases it has been recommended to employ antiseptic drugs, which by counteracting and removing the poison allay the unfavorable symptoms, among them the profuse perspirations. Creosote, sulphocarbolates, and other similar remedies have been employed for this purpose.

Bathing the surface of the body with weak acid solutions assists in allaying perspiration and preventing the "night sweats," for it is known that all acid solutions will lessen the secretion of acid-secreting glands. Dilute sulphuric, or acetic acid, or vinegar, applied at bedtime, and in severe cases repeated a short time before the expected "sweat," will allay the trouble and at the same time prove most refreshing. Hot solutions are said to be more effective, and it has been recommended to employ cayenne pepper in hot vinegar in rebellious cases.

Beaumont Small.

ANTITHERMIN. — Phenyl-hydrazine-levulinic acid, $CH_3C\ C_6H_5N_2H,C_2H_4COOH$. This is prepared by acting on a solution of phenylhydrazine in acetic acid, with levulinic acid. The resulting crystals are colorless, without taste, and are practically insoluble in water. They are slightly soluble in alcohol and readily so in ether. Their melting point is 108° C. (226° F.). This drug was introduced in 1887 by Nicot as a new antipyretic, and was afterward recommended by Drobner in the high temperature of pulmonary tuberculosis. He gave it in doses of gr. viiss. to x., but on account of occasional untoward symptoms, such as pallor, sweating, headache, and general depression, gr. iij. is advised as the maximum safe beginning dose. Antithermin has been used to a slight extent in other cases of fever, but has not found favor with the medical profession.

W. A. Bastedo.

ANTITOXINS; ANTITOXIC SERA.—The word antitoxin is at present usually restricted to substances found in the blood of animals which neutralize the toxins produced by bacterial or other cells. Other substances exist which are slightly antitoxic. These are found in old cultures, and Bolton developed them from toxins by means of electricity. An antitoxin is, to a large degree at least, specific in its effects on poisons; that is, it acts only, or at least chiefly, upon the toxins produced by one species of organisms.

Thus, a given quantity of antitoxic serum from a horse made immune to diphtheria will absolutely neutralize a number of fatal doses of diphtheria toxin, so that the mixture injected into an animal will prove harmless.

The same antitoxic serum mixed with the toxin from tetanus bacilli will have no appreciable neutralizing effect. In a few instances some have reported an antitoxin to have an effect on more than one toxin, but even here this effect is always much greater upon some one than upon the others.

Antitoxins are present to some extent in the blood of animals which have not passed through an infectious disease or been injected with bacterial or other cell poisons. For instance, horses usually have more or less of a substance antitoxic to the diphtheria toxin. Thus it will require 5 c.c. of the blood of one horse to protect a 250 gm. guinea-pig from ten fatal doses of diphtheria toxin, while in another $\frac{1}{30}$ c.c. will suffice. The blood of these same horses may have no neutralizing effect upon tetanus toxin.

Whether these antitoxic substances present in small amounts in normal blood are the same as those present in larger amount in the blood of immunized animals, we as yet do not know. Neither in their chemical nor in their physiological properties can we detect any difference.

THE NATURE OF ANTITOXINS.—Up to the present time we know only that they seem to have the properties of globulins. If it were not for the fact that we have them present in normal blood, we might, in order to account for

their specific qualities, consider them as partly satisfied combinations of globulins and specific toxins, but as they occur without the presence of toxins this theory seems to be excluded.

Blood from either normal or immunized animals contains a number of globulins, and these all, when the blood is antitoxic, prove antitoxic also. By no known method can we separate the antitoxin from the globulin, so that if antitoxin be not a globulin it is at least a substance very closely allied to it. Exactly how the antitoxins are produced we do not know, but we believe them to be cell products. Different antitoxins may be produced by different cells.

A relation which exists between the amount of antitoxin in the blood of an immunized animal and the amount of globulins has been noted, in the tests of the different horses under the care of the Department of Health, by Atkinson. He found that the globulin increased and decreased roughly as the antitoxin increased and decreased.

Antitoxins are only fairly stable substances. In sera antitoxins either slowly or quickly deteriorate, largely according to the conditions under which they are kept, but partly also in proportion to the abundance of certain blood ferments. In sterile serum, kept cold and free from access of air, antitoxins deteriorate very slowly, diminishing from ten to fifty per cent. in a year. Exposed to light, air, and slightly elevated temperature, they quickly become altered, and especially so if exposed to heat above 50° C. Exposed to 70° C. for ten minutes, a large portion of the antitoxin in a solution is destroyed.

As the antitoxins of diphtheria and tetanus have been the most studied and are by far the most important of the known antitoxins, they will be considered in detail as types of the others.

Both of these antitoxins have the power of neutralizing their corresponding toxins, so that when a certain amount is injected into an animal before or together with the toxin the poisonous effect of the toxin is removed. There is still a great difference of opinion as to whether antitoxin acts by direct chemical neutralization of the toxin or indirectly on the cells. The facts in favor of a direct action of antitoxins upon their corresponding toxins have recently been briefly summarized by Cobbett as follows.

1. Certain reactions have been observed to take place between these substances outside the animal body (venom, ricin, crotin, tetanus toxin, diphtheria toxin, and their corresponding antitoxins).

2. Various attempts by filtration, chemical means, and heat to separate the toxins and antitoxins from neutral mixtures have been failures. Partial successes have, at least in some instances, been shown to depend upon the fact that insufficient time for the complete union of toxins and antitoxins was allowed, separation being no longer possible if this were granted.

3. The accuracy of the titration of toxins and antitoxins to within one per cent. of error.

4. The fact that to save an animal from one thousand fatal doses of toxin requires little more than a hundred times as much antitoxin as is required to fully protect for ten fatal doses, the resistance of the animal itself accounting for the difference.

5. The fact that the potency of antitoxin is greatly increased if it is allowed to remain for a sufficient time in contact with the toxin at a suitable temperature.

On the other hand, the conclusions which Buchner and Roux drew from their experiments have been shown to have been based, partly at least, on a misconception, for they ignored the capacity of an animal to deal with a certain minimal quantity of poison, and consequently made no distinction between what seemed to be a physiologically neutral and a completely neutral mixture.

The facts now known, therefore, indicate rather strongly that the antitoxins of tetanus, diphtheria, the plague, and cholera, of snake poison, of ricin, etc., enter into direct chemical combination with their respective toxins—a combination which is, perhaps, not exactly comparable to that of an acid with an alkali; for, as we have seen, it is a much slower one, but one which possibly—as Ehrlich has suggested—more closely resembles the formation of a double salt. Some facts seem to indicate that the antitoxin has a stronger affinity for toxin than the toxin has for the cells. Many points, however, are still far from clear as to the manner in which both toxins and antitoxins act.

The Persistence of Antitoxin in the Blood.—About five days after the absorption of toxin has ceased, either after a natural disease or after an artificial infection, the production of antitoxin in the body stops, except that which may be normally produced, and the amount in the blood gradually lessens, partly from its elimination by the urine, milk, etc., and partly, perhaps, by its destruction in the blood.

According to the amount of antitoxin present will be the length of time required for the elimination of the antitoxin. The blood of an animal highly immunized may retain appreciable amounts of antitoxin for from three to six months.

When animals are immunized with the antitoxic sera of animals of other species, the antitoxin is more quickly eliminated than when sera from the same species are employed. For this reason the immunizing effect of sera in man against diphtheria, tetanus, and the few other infections for which we have antitoxins, is of short duration, less than if antitoxins had been developed from toxins injected. Thus, immunization of a child with 300 units of antitoxic horse serum insures immediate safety, but only ten days of certain protection from diphtheria.

The diphtheria and tetanus antitoxins are the only two used extensively in treatment. All the other protective sera are largely bactericidal in their action and owe what little or doubtful value they have to this characteristic. The most important of them will be touched upon in the article on immunity, under the bactericidal properties of the blood.

The use of antitoxins in the prevention and treatment of diphtheria and tetanus is so important that some details as to how to choose and administer the sera may be of value. All antitoxic sera must be injected subcutaneously, or intravenously, for they are only very slightly absorbed by the stomach or intestines. The sera should be clear and have no odor except in cases in which an antiseptic has been added, such as trikresol or carbolic acid. In the Department of Health laboratory in New York we add no antiseptic whatever. Let us now consider in detail the diphtheria antitoxic serum. The dosage is regulated by units of effect and not by weight, for we have not as yet absolutely isolated antitoxin. A unit is the amount of antitoxin which protects a 250-gm. guinea-pig from one hundred fatal doses of diphtheria toxin.

Diphtheria antitoxic serum is put up in different "grades," the lower grades having 100 to 300 units in each cubic centimetre of serum, the higher grades having 400 to 600 units. Other things being equal, the higher grades are better and more convenient than the lower ones. In the laboratories of the Department of Health of New York City we have until recently striven for a serum which had the greatest possible amount of antitoxin in each cubic centimetre. The better way, however, is to get the highest grades of serum which will produce few or no rashes, for, without regard to the amount of antitoxin present, some serums produce deleterious results, while others produce almost none. Samples of all bleedings should be used first, if possible, in a few mild cases of diphtheria, and then only those serums which pass this test without producing marked rashes should be further used.

The Amount of Diphtheria Antitoxin to be Administered and the Number of Injections in a Single Case.—There is still some difference of opinion among competent observers as to the answer to these questions. For immunization, 200 units in infants and 500 in adults will suffice. In treatment, our practice is the following: Cases seen early, in which the onset is mild, 1,000 units. Cases seen early, in which the onset is severe, shown either by local signs, such as swelling, hyperæmia, or the extent of the exudate, or by constitu-

tional symptoms, 2,000 to 4,000 units, according to severity. Cases seen after the disease has progressed so far that its probable local extent can be guessed, mild cases, 1,000 to 2,000 units, according to the size of the patient; moderate cases, 2,000 to 3,000 units; severe cases, showing necrotic membrane, swollen glands, or laryngeal stenosis, 3,000 to 4,000 units.

The effects to be expected from the antitoxin are, that the local disease should not extend, that the swelling and hyperæmia should lessen and the constitutional symptoms abate. If twelve hours after the injection these changes have not begun clearly to manifest themselves, the injection of antitoxin should be repeated. If in twelve hours more no decided improvement occurs (which rarely happens, excepting in cases already very severe when first injected, and in some of the laryngeal cases complicated by bronchial or lung involvement), still a third dose should be given; some even advise a fourth. The extent of the disease, rather than the size of the patient, guides the dose; still size should be considered somewhat, and I should not advise, in a child under one year, more than 3,000 units in a single injection, and in one under six months not over 2,000 units. If the cases are severe, injections should be repeated just as in larger children. In adults attacked with malignant diphtheria the largest doses mentioned should be used and fearlessly repeated. With the serums as now used, these large doses have produced in a small percentage very disagreeable results, namely, rashes, fever, and in a few joint inflammation.

Whether some samples of serum may or may not cause, along with their beneficial effects, really serious deleterious effects, is still undetermined; but we do know that many samples of serum produce practically not even disagreeable effects. Thus, I have seen sixty cases treated, with only one rash. I have also seen, with serum obtained from another bleeding, twenty treated, with ten rashes. To select good serum only and throw away the most irritating, is only a matter of testing in trial cases. At present I see no other way of eliminating from sera the substances which produce rashes and other deleterious effects. The precipitate of antitoxin and globulin thrown down by magnesium sulphate is just as liable to produce rashes as the entire serum, and at present we know of no way to separate antitoxins from globulins.

The Production of Diphtheria Antitoxin for Therapeutic Purposes.—As a result of the work of years in the laboratories of the Health Department of New York City the following may be laid down as a practical method:

The strongest diphtheria toxin possible should be obtained by taking a very virulent culture and growing it in slightly alkaline two-per-cent. peptone bouillon. The culture, after a week's growth, is to be removed, and, after it has been tested for purity by microscopical and culture tests, is then to be rendered sterile by the addition of ten per cent. of a five-per-cent. solution of carbolic acid. On the following day the sterile culture is filtered through ordinary sterile filter paper and stored in full bottles in a cold place until needed. Its strength is then tested by giving a series of guinea-pigs carefully measured amounts.

The horses used should be young, vigorous, of fair size, and absolutely healthy. A number of such horses are severally injected with an amount of toxin sufficient to kill ten thousand guinea-pigs of 250 gm. weight. After from three to five days, so soon as the fever reaction has subsided, a second subcutaneous injection of a slightly larger dose is given. With the first three injections of toxin about 10,000 units of antitoxin are given. If antitoxin is not mixed with the first doses of toxin, only one-tenth of the doses advised is to be given. At intervals of from five to eight days increasing injections of pure toxin are made, until, at the end of two months, from ten to twenty times the original amount is given. There is absolutely no way of judging which horses will produce the highest grades of antitoxin. Upon a very rough estimate I may say that those horses which are extremely sensitive and those which react hardly at all are the poorest, but even here there are exceptions. The only way, therefore, is at the end of six weeks or two months to bleed the horses and test their serum. If only high-grade serum is wanted, all horses that give less than 150 units per cubic centimetre are discarded. If moderate grades only are desired, all that yield 100 units may be retained. The retained horses receive steadily increasing doses, the rapidity of the increase and the interval of time between the doses (three days to one week) depending somewhat on the reaction following the injection, an elevation of temperature of more than 3° F. being undesirable. At the end of three months the antitoxic serum of all the horses should contain over 200 units, and, in about ten per cent., as much as 600 units, in each cubic centimetre. Very few horses ever give above 1,000 units, and none so far has given as much as 2,000 units per cubic centimetre. The very best horses continue to furnish blood containing a large amount of antitoxin for several months, and then, in spite of increasing doses of toxin, the amount of antitoxin gradually decreases. If every nine months an interval of three months' freedom from inoculations is given, the best horses furnish high-grade serum for from two to four years.

The Production of Tetanus Antitoxin.—The tetanus antitoxin is developed in the same manner as the diphtheria antitoxin—by inoculating the tetanus toxin in increasing doses into horses. The toxin is produced in bouillon cultures grown anaërobically. After ten or fifteen days the culture fluid is filtered through porcelain, and the germ-free filtrate is used for the inoculations The horses receive 0.5 c.c. as the initial dose of a toxin of which 1 c.c. kills 250,000 gm. of guinea-pigs, and along with this a sufficient amount of antitoxin to neutralize it. The antitoxin is added to the first few doses. In five days this dose is doubled, and then every five to seven days larger amounts are given. The dose is increased as rapidly as the horses can stand it, until they support 700 to 800 c.c. or more at a single injection. After some months of this treatment the blood of the horse contains the antitoxin in sufficient amount for therapeutic use. When the animals' temperatures are normal and they have recovered from the dose of toxin last given, they are bled into sterile flasks and the serum collected.

Technique of Testing Tetanus Antitoxic Serum for Value in Antitoxin.—Tetanus antitoxin is tested exactly in the same manner as diphtheria antitoxin, except that the unit of measure is different. A unit in the German standard is the amount of antitoxin needed to neutralize 4,500,000 fatal doses of toxin for 1 gm. of white mouse. In the French method the amount of antitoxin which is required to protect a mouse from a dose of toxin sufficient to kill in four days is determined, and the strength of the antitoxin is stated by determining the amount of serum required to protect 1 gm. of animal. If 0.001 c.c. protected a 10-gm. mouse, the strength of that serum would be 1 to 10,000. Guinea-pigs are frequently used in place of mice. Knorr's method of preserving toxin is by precipitating it with saturated ammonium sulphate and drying and preserving the precipitate in sealed tubes. As required, it is dissolved in ten-per-cent. salt solution, as above stated. For small testing stations the best way is to obtain some freshly standardized antitoxin and compare serums with this.

The Dosage of Tetanus Antitoxin.—For immunization, one dose of from 5 to 10 c.c. of a serum of a good strength, such as 1 to 100,000,000, will suffice unless the danger seems great, when the injection is repeated at the end of a week. For treatment, it is well to begin with from 30 to 50 c.c., and then, according to the severity of the case, give from 20 to 50 c.c. every six to twenty-four hours until the symptoms abate. In the gravest cases no curative effect will be noticed from the use of the serum. It is sometimes injected into the lateral ventricles or even into the brain substance. Both the theoretical reasons for, and the actual results obtained from, this method of treatment, are open to criticism. The first dose, in severe cases, may be given intravenously. *William H. Park.*

ANTITUSSIN.—Difluor diphenyl $(C_6H_4F)_2$. This is a white crystalline powder with a pleasant aromatic odor suggestive of dill seed. It is insoluble in water and soluble in alcohol, ether, chloroform, and fixed and volatile oils.

Originally introduced as an antispasmodic and sedative in whooping-cough, it was reported by the early observers to be of little value in that condition. Recently, however, Max Heim has published observations on sixteen cases in which he found speedy and surprisingly complete relief following its use. His conclusions were that it lessens the acuteness of the attack, that it markedly loosens the phlegm and mucus, and that the duration of the disease is reduced from several weeks to a few days, or at most two weeks. His formula is difluor diphenyl 5, vaseline 10, adeps lanæ hydrosus 85, and this he uses by inunction over the neck or interscapular region after thoroughly cleansing the skin and rubbing it with a rough towel. Antitussin is not administered internally, as it deranges the stomach. The dose by inunction is from ʒ ij. to ʒ iij.

Besides its use as above it has been found valuable as an antiseptic, and for this purpose is applied as a five to twenty per-cent. ointment or dusting powder. Thimm uses it in venereal ulcerations, after cauterizing the ulcer with carbolic acid.

W. A. Bastedo.

ANUS AND RECTUM. (SURGICAL.)—No rectal examination in women can be considered at all complete which does not include bimanual exploration of the pelvis, and the examiner must acquire the same skill in this as the gynæcologist, though he will more frequently explore with one finger in the rectum than in the vagina. It is also true that many obscure cases both in men and in women will at once become clear under anæsthesia. So little does diagnosis depend upon any specula that we need not stop to consider these instruments.

This does not apply to the Kelly long tubes for high rectal and sigmoid exploration. These may in certain cases be of great value both for diagnosis and for treatment. I have modified his original design so as to make the long tube resemble the ordinary valve speculum except in its length. The instruments are difficult to use and not devoid of danger, but in expert hands they occasionally yield excellent results.

HEMORRHOIDS.—These may be divided into external and internal. External hemorrhoids present themselves in two perfectly distinct forms. The first is shown in Fig. 220, and is a venous tumor, produced by the rupture of an external hemorrhoidal vein and the extravasation of its contents. Such a tumor forms suddenly, is exquisitely painful, and sometimes looks and feels like a large black grape; it will slowly subside and disappear when treated by rest in bed and applications of powdered ice in a rubber *baudruche*, with the internal administration of a saline cathartic. The most appropriate treatment, however, is a free incision with a small, sharp-pointed, curved bistoury, the tumor being transfixed and incised in the direction of the radiating folds of the anus. As a result of the incision, a small, round clot—the pressure of which has caused all the suffering—may be turned out of its bed.

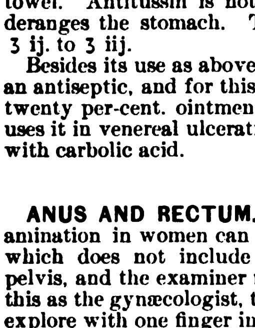


FIG. 220.—External Venous Hemorrhoid. (Smith.)

The other form of external hemorrhoid is a cutaneous and not a venous tumor, and is well shown in Fig. 221. This is often spoken of as a condyloma, but that name is better applied to another condition. Such a tumor as this is composed of skin and connective tissue. It often results directly from the irritation caused by the first variety, and is, in fact, the remains of the venous tumor; or it may be caused by the irritation of some ulcerative disease within the rectum. It is not painful unless it happens to become acutely inflamed, and is generally best left alone. When operating for more serious trouble, with the patient under ether, I occasionally snip them off with a pair of scissors, but when a patient applies for relief from them alone, I usually advise non-interference. The wound made by removing them is painful and they generally do little harm.

FIG. 221.—External Cutaneous Hemorrhoids. (Esmarch.)

Internal hemorrhoids are those which arise, within the sphincter muscle, from the internal hemorrhoidal vessels. They present many variations in structure. One perfectly distinct variety is known as the capillary. This is in reality an erectile tumor composed of the terminal branches of the arteries and veins, and of the dilated capillaries which unite them. This form of tumor is never of large size, and never projects far into the cavity of the rectum. It is, in fact, much like a nævus of the scalp. It may be situated high up in the rectum, but is generally near the anus; the surface is granular, and the membrane covering the vessels is so thin that it may be broken by each act of defecation. Such a tumor never appears outside the anus unless the protrusion is caused by some other affection, but it may be seen by carefully pulling open the parts with the fingers, and from some part of its mulberry-like surface there is apt to be a jet of arterial blood, coming *per saltem*. This is, above all others, what is most properly called the "bleeding pile."

This form of hemorrhoid may be cured by a single thorough application of fuming nitric acid, and it is the only form in which this plan of treatment is likely to be of permanent benefit.

In the other forms of hemorrhoids there is a distinct tumor, sometimes of considerable size, made up of mucous membrane more or less eroded, of connective tissue, and of blood-vessels. These tumors may cause decided symptoms before they are sufficiently large to protrude from the anus. One of the first is an unsatisfied feeling after defecation, as though the rectum were not fully emptied; and this is explained by the increase in size of the tumors caused by defecation. This feeling passes away after a few moments, when the circulation has again become natural. Other symptoms are pain, more or less obscure, and referred to the loins and thighs; difficulty in micturition; diminished sexual appetite and power; hemorrhage; and sometimes a peculiar train of nervous symptoms referred to the legs—symptoms which will deceive both patient and physician into the belief that an ataxia is developing. After the tumors reach a stage which causes them to protrude beyond the sphincter in defecation, the resulting symptoms are well known. In ordinary cases the patient will reduce the tumors himself after each protrusion. They may, however, become strangulated and be entirely beyond the patient's power of manipulation. In such a case, after a period of rest, and after the relief which may follow a spontaneous escape of blood, the hemorrhoids may return of themselves or be put back by the patient.

If the strangulation be more intense, gangrene may set in and a part of the mass may slough, or a portion may suppurate. Under such circumstances there will be great pain, and more or less constitutional disturbance, with fever. The gangrene is very evident, both to the eye and the sense of smell, from the greenish or blackish color and fetid odor of the part, and is rather a favorable termination to the trouble, as it generally results in a radical cure.

TREATMENT.—The treatment of internal hemorrhoids is both palliative and curative, and it is a great advantage to the surgeon to know what can be done for a timid pa-

tient without having recourse to anything which may properly be called an operation. The first thing is to secure a daily natural evacuation of the bowels, and this without medicine if possible. The diet should be plain. Highly seasoned dishes, gravies, salads, old cheese, etc., all alcoholic drinks, and any excess in tobacco should be strictly interdicted. If necessary, a laxative may be added to the daily diet, and this may be either a glass of mineral water before breakfast, or a drachm of compound licorice

FIG. 222.

powder at night. The local treatment consists mainly in the use of astringents and cold water. A cold sitz bath every morning after stool is one of the best of all methods of preventing and relieving hemorrhoids, and cold, or even ice water should be freely applied after each passage. The best astringent is the subsulphate of iron in the form of ointment or suppository (ʒ i. to ℥ i. for ointment, and two or three grains in a suppository). By these means, when followed with care and patience, the worst case may be greatly improved. Although they are given simply as palliative measures, they will sometimes be followed by such relief as to convince the patient that he is radically cured.

Of all the different methods of radically curing hemorrhoids I shall describe but two. These are the ones which have given the best results, and from them each may choose. By either of them every case may be cured.

(*a*) The treatment by the ligature, as practised by most surgeons at present, consists in cutting through the greater part of the base of the tumor with the scissors, and tying a strong ligature around the remainder, which is supposed to contain the larger blood-vessels. As in all operations on the rectum, the bowels should be thoroughly cleared by a cathartic on the previous day and by an enema just before operating. The patient should be etherized and placed in the lithotomy position, and the sphincter gently but forcibly dilated till it loses its contractile power. A speculum may or may not be used, as the operator prefers. Each tumor is seized with a long toothed forceps, such as is shown in the cut (Fig. 222), and is then drawn out of the anus. Holding the forceps in his left hand, the operator separates the tumor from its attachments by cutting with a strong pair of scissors in the line of junction of the skin and mucous membrane from below upward until only a pedicle remains. The forceps are then transferred to an assistant, and a strong silk ligature tightly tied around what remains of the tumor, and the hemorrhoid itself may then be cut off at a short distance from the ligature, in order that as much dead tissue as possible shall be removed from the rectum. Each hemorrhoid is thus treated in succession, and after all are removed and the ligatures cut off close, a suppository of opium and belladonna is introduced and a T-bandage tightly applied over a compress of lint and a napkin.

The after-treatment is a matter of a good deal of importance. It is not well to allow the bowels to be confined more than three days, and the first passage should be assisted by a laxative. Much less pain will be caused by a soft passage on the third day after the operation than will result from confining the bowels for ten days or a fortnight, as is usually done. Under the latter circumstances the suffering caused by the first passage is often atrocious. It is not a good plan to try to introduce suppositories into the painful rectum after the operation. The ligatures will generally come away at the end of a week or ten days, and the patient should be kept in the bed or on the lounge for a week longer till the ulcer caused by the separation of the slough has had time to heal. Nothing has been said about primary hemorrhage. It is sometimes considerable, and much that is theoretical in character has been said about the chief vascular supply of a hemorrhoid being at the upper end. The incision made with the scissors before the ligature is applied sometimes bleeds very freely, and requires the free use of lint within the bowel after the operation is completed. The removal of this wad, in those cases in which it has been found necessary to introduce it, is an additional source of pain.

This operation, though generally very satisfactory, is open to certain objections. These are: occasional severe constitutional disturbance with nervous excitement, frequent pulse, loss of sleep, pain sufficient to demand the use of morphine for days, and obstinate retention of urine, which may render catheterism necessary for a fortnight; and, finally, undue contraction after the operation, which will entail the use of the bougie.

(*b*) The other operation, which gives the best results, is done with the clamp and cautery, and consists in drawing down the tumor, embracing its base tightly in the clamp, cutting off such an amount that a good-sized stump shall be left, and cauterizing this thoroughly with the hot iron. It is important to isolate the tumors well, so as to compress them easily and completely; and, in cases in which the hemorrhoid joins abruptly the hypertrophied skin, a groove may first be made with the scissors, so that the compression of the neck of the tumor may be more effectual. After the cautery has been very thoroughly applied, at a black heat, the blades of the clamp should be gradually released by the screw. Should any bleeding occur the clamp must be again screwed up, and the cautery applied more thoroughly. This may be necessary several times. The advantages claimed for this operation over that with the ligature are: greater safety to life, greater freedom from suffering, more rapid recovery, less danger of pyæmia, of ulceration, and of embolus, and less constitutional disturbance after the operation. The operation is equally applicable to cases of prolapsus.

Treatment by Minor Surgical Methods.—Many methods have been devised by which hemorrhoids may be radically cured by office treatment, without general anæsthesia or confinement to bed. Perhaps the one best known at the present day is that which requires the injection of a solution of carbolic acid into the tumor—an uncertain and dangerous plan, which has been generally abandoned by the regular surgeons because of the impossibility of limiting its effects. If a patient prefers this office treatment without what he or she considers a surgical operation, hemorrhoids may be gradually destroyed exactly as the nose and throat specialists remove polypi and obstructions from the air passages. The treatment will require time, but it is perfectly efficient and gives great satisfaction to those who can avail themselves of its advantages. The same treatment applies in other affections also—fissures, pruritus, small fistulæ, etc.

FIG. 223.—First Variety of Prolapse. (Mollière.)

PROLAPSE.—There are four distinct varieties of prolapse, which must be carefully distinguished from one another as regards the plan of treating them, for the same operation which will cure one variety may lead to a fatal result in another which to the eye closely resembles it. The first consists of a protrusion of the mucous membrane alone, and is sometimes spoken of as partial prolapse, because only a part of the coat of the bowel comes

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out of the body. It is shown in Fig. 223. It is a mere everting of the mucous membrane of the lowest portion of the rectum, rendered possible by the laxity of the submucous connective tissue. It is the most common of all the forms, and is most frequently found in children between the years of two and four. It always comes on gradually, and it may be partial or complete as regards the entire circumference of the anus. It appears as a scarlet or livid mass (depending upon the degree of contraction of the sphincter) covered with the natural secretion of the bowel, directly continuous with the skin on one side and with the mucous membrane on the other, and arranged in folds which radiate from the central aperture toward the circumference. It is at first spontaneously reducible, or at least may easily be replaced by slight pressure, and remains reduced till the next defecation; but as the amount of prolapsed membrane increases, the difficulty in reduction becomes greater, and finally the mass may be out of the body most of the time from distention and loss of power of the sphincter. In this condition the tumor is liable to become inflamed, œdematous, and irreducible, and the patient is in a very unhappy plight.

The first step in the treatment of this form of prolapse is generally the reduction of the mass. If the patient be in the condition last named all operative interference should be postponed; no attempt at reduction need be made, the patient should be confined to his bed, cold applications should be used freely, and the tumor should be smeared with an ointment of equal parts of the extracts of opium and belladonna. After a week of this treatment the tumor will probably be in a condition in which it may either be replaced or be removed, and the surgeon will then be able to judge something of the amount of tissue to be removed, which is not possible when all the parts are œdematous. In ordinary cases the tumor may be reduced by gentle taxis. If this does not succeed, ether should be given at once and a radical operation performed. In adults, when the taxis has failed and both ether and operation are declined, there is nothing to do but keep the patient on his face in bed with a pillow under the pelvis, apply warm poultices with the ointment mentioned, and trust to time to relieve the condition.

The palliative treatment is directed entirely toward diminishing the frequency and amount of the prolapse, and a cure may sometimes, especially in children, be obtained by these means without operation. They consist briefly in directing the act of defecation to be performed in the recumbent posture, and in advising the use of laxatives to prevent straining, the avoidance of any source of irritation which will cause frequent passages, and the use of astringent washes each time the bowel protrudes. The best astringent is cold water or a cold solution of alum (ʒ i. to ℥ viij.). An astringent injection may also be given every night with advantage, the fluid being allowed to remain in all night.


FIG. 224.—Prolapse Composed of All the Coats of the Rectum. (Bushe.)

In children a very effectual means of cure is the application of fuming nitric acid to the prolapsed part. The bowel should be thoroughly dried with a towel, and the acid applied with a small stick all over the mucous membrane. The bowel should then be replaced, a pad of lint should be firmly applied, by means of a broad strip of adhesive plaster, over the nates, sufficient opium should be given to confine the bowels, and the child should be kept in bed. In a large proportion of cases the cure will be complete after a single application, unless a polypus be the exciting cause of the trouble. This treatment is not equally successful in adults, and in old persons deep and dangerous sloughs may result, which may lead to serious hemorrhage. In them the treatment by linear cauterization is much preferable. It consists in making several deep cauterizations in lines radiating from the centre of the prolapse toward the circumference. Paquelin's cautery with the fine-pointed bent tip is the proper instrument to employ, and after several such cuts have been made it is a good plan to burn through the sphincter on each side, to allow of contraction. This operation must be done with judgment, and the amount of cauterization must correspond with the amount of prolapse. In old and inveterate cases the fault is generally, however, in not making the cauterizations sufficiently extensive. A portion of the mucous membrane is burned off, but the cuts do not extend into the connective tissue around the anus, as they should.

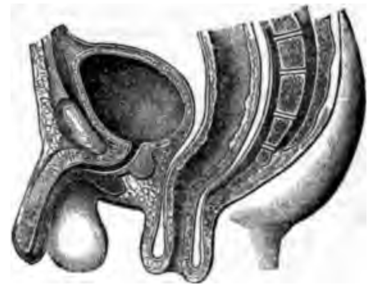
FIG. 225.—Second Variety of Prolapse. (Mollière.)

The second variety of prolapse is that composed of all the coats of the rectum—mucous, submucous, and muscular—and is shown in Fig. 224. The essential point in the consideration of this form of the disease is to remember that the prolapse may contain peritoneum; and it follows, from the anatomy of the parts, that the peritoneal pouch will be larger in front than behind. In the pouch thus formed may be located coils of small intestine, or even the uterus or an ovary. In this form of prolapse there is no groove or sulcus, and its absence is therefore no proof of the absence of peritoneum. Its anatomical characters are well shown in Fig. 225. This variety of the disease generally follows the first, though it may come on suddenly from violent straining. It is distinguished from the first by its size, by greater firmness and thickness as ascertained by the touch, possibly by resonance on percussion, or by the gurgling of gas in a contained loop of small intestine, by its conical shape, and by the slit-like orifice which is generally drawn to one side by the attachment to the vagina, or by the binding down of the meso-rectum.

FIG. 226.—Third Form of Prolapse. (Bryant.)

It is evident that an operation which might cure the first variety might easily end fatally in this one, by reason of the presence of peritoneum, and that the possibility of this complication must always be borne in mind. The treatment by linear cauterization is the safest, and the cuts should be made into the substance of the sphincter after the tumor has been reduced, and not into the tumor itself. Should this fail, the tumor must be amputated with subsequent circular enterorrhaphy above the external sphincter. The palliative treatment is the same as for the other variety.

The third and fourth varieties will be described together, because they do not differ from each other in their nature, but simply in their extent and location. To both the term invagination is properly applied, because of the ensheathing of one part of the bowel within another, which is shown in Fig. 226. In the third variety the telescoping occurs near the anus, the intruded portion appears at the anus, and the sulcus between the extruded portion and the lower part of the rectum may be felt with the finger. Its depth forms an indication of the length of the contained part. When a portion of the bowel still further removed from the anus has become invaginated into that immediately below, the included portion may or may not descend sufficiently near to the

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anus to be felt by rectal touch, and the sulcus may not be apparent. This constitutes the fourth variety, and is generally known as intussusception. In the treatment of intussusception we enter at once into the domain of abdominal surgery, and into one of its most difficult departments, viz., that of intestinal anastomosis. This, I have always claimed, the specialist in the rectum should be able to do, but the limits of this article will not permit a study of these cases.

Abscess and Fistula.—Abscesses near the rectum may be divided into the superficial, those of the ischio-rectal fossa, and those of the pelvis.

An abscess of the ischio-rectal fossa is bounded by the levator ani muscle above, the skin below, the rectum on one side, and the adjacent tuberosity of the ischium on the other. An abscess of the pelvis, on the other hand, is located in the lax connective tissue around the upper portion of the rectum above the levator ani. It may assume vast proportions, blending laterally with the subperitoneal connective tissue of the iliac fossa, and burrowing in almost any direction in the true pelvis.

The causes of deep rectal abscess are various. Traumatism is perhaps the most frequent, and the injury is generally internal rather than external, being caused by the point of a syringe or foreign body rather than by kicks or falls. Such an abscess may also be due to the injury inflicted by the fœtal head in parturition, and in such a case it may be a difficult matter to distinguish the disease from puerperal inflammation. It may also be secondary to diseases of the urinary organs, and it may result from rupture, ulceration, or perforation of the rectal wall in connection with stricture. Again, it may result from an inflammation of the submucous tissue with the production of pus which first opens into the bowel and forms an internal fistula, and subsequently extends outward and forms a large abscess. Finally, such abscesses may, so far as their origin is concerned, have no connection with the rectum; they may be due to disease of some neighboring part, such as appendicitis, or to necrosis of some adjacent bone; or perhaps no adequate cause can be found, so that for lack of knowledge it may become necessary to set them down as idiopathic.

In abscess of the pelvis, when not due (as it generally will be) to septic endometritis, the symptoms are often obscure and seldom characteristic. There is more or less vague pain in the pelvis or lumbar region, which is seldom intense and is generally increased by defecation. Fever may be entirely absent, but if it is present it is more apt to be continuous than very high in degree, and chills are only occasionally met with when pus is formed. In addition there is more or less general malaise, and the vesical symptoms (retention and incontinence of urine) are apt to be marked. The diagnosis must rest chiefly upon the result of careful bimanual pelvic examination. An abscess of the ischio-rectal fossa may at its commencement be marked by the same obscure symptoms, but later the skin becomes red and œdematous, sometimes over a large part of the buttock, the pain is very severe, and rectal examination is impossible. In abscess of the pelvis immense collections of pus may form and burrow in any direction. In men the pus generally follows the course of the bowel, involves secondarily the ischio-rectal fossa, and makes its way through the skin at some distance from the anus, possibly over the trochanter or out on the buttock. In women it is more apt to pursue a contrary course, and usually bursts through the rectum or the vagina. An abscess of the ischio-rectal fossa generally breaks both upon the cutaneous surface and into the bowel at some distance from the anus, while one in the male pelvis is just as likely to open into the bladder or the peritoneal cavity as into the bowel.

The great question in treating an abscess of the ischio-rectal fossa is to prevent the formation of a fistula. This can generally be done if the proper course be followed, but the treatment must be prompt and efficient. It consists in etherizing the patient as soon as the diagnosis is made, and, without waiting for fluctuation or even for the formation of pus, in making a free incision into the centre of the diseased area, thoroughly cleaning out any cavity that may have formed, breaking down all bridles of sloughing tissue, laying open all pockets, washing out the cavity with carbolic acid, and stuffing it with lint. If this be properly done the formation of a fistula will be prevented in the majority of cases. If the abscess be left to itself, or even partially opened, a bad form of complete fistula is pretty sure to follow. The treatment of an abscess of the pelvis in men is not so simple, the disease being more serious and the prognosis more grave. If possible the abscess cavity should be opened with the knife through the rectum or by way of the abdominal cavity. In women it should be opened through the vagina. Here again we enter upon the domain of abdominal surgery, to which properly belongs the whole question of the comparative value of vaginal and abdominal cœliotomy for the relief of pelvic inflammation.

Fig. 227.—Varieties of Fistula. (Gosselin.) A, anus; R, rectum; B, complete fistula; C, blind internal fistula; D, blind external fistula.

Fistula.—A fistula which is not due to perforation of the rectal wall from within is the result of a previous abscess, and therefore the consideration of one leads directly to that of the other. Like the abscesses from which they arise, such fistulæ may well be divided into superficial and deep; or into those of the anus which are subcutaneous and involve at most only a few fibres of the external sphincter, and those of the rectum and pelvis, which open into the bowel at a higher point or on the surface at a considerable distance, perhaps, from the anus. Both the superficial and deep may be divided into the complete, or those which open both into the bowel and on the surface; the external, which open only on the skin; and the internal, which have an opening only within the bowel (Fig. 227). Deep or submuscular fistulæ differ greatly in their extent and gravity. In them the track is large and often double or branching, and the external opening may be far away from the anus. The whole perineum and even the gluteal region will sometimes be found pierced with openings. In these the internal orifice does not in all cases mark the superior limit of the fistulous track. This may run up a distance of several inches alongside the bowel, under the mucous membrane, while the internal orifice is only just within the sphincter (Figs. 228 and 229).

Fig. 228.

Fig. 229.

Fistulæ with Double Tracks. (Mollière.)

Fig. 228.- AB, Deep submuscular track resulting from an ischio-rectal abscess; AI, submucous track running up and down the bowel.

Fig. 229.—DE, Subtegumentary and submucous fistula with an internal and an external opening. DF, deep submuscular track having same internal, but separate external opening.

Blind internal fistulæ, or those which have an opening only into the bowel, have a somewhat special pathology. When such a fistula is caused by an abscess, it is generally one of the deep variety, which has opened into the rectum high up and continues to discharge in this way. The opening may, however, be the result of ulceration, and the track a secondary consequence. A small ulcer which shall perforate the mucous membrane and result in internal fistula may be due to several causes: to rupture of an inflamed internal hemorrhoid; to the inflammation of one of the lacunæ just above the sphincter—an inflammation caused by the lodgment within it of an irritating

particle; to the application of strong acids or any other traumatism; or to tuberculous ulceration. Such a condition is a very painful one. The opening, which may be large enough to reveal a distinct loss of substance to the touch, catches and retains particles of fæces, which cause a burning pain that may last many hours after defecation. As a result of the ulcer, an abscess forms after a time, and is accompanied by the usual symptoms. When this is small, and the induration not extensive, a speculum examination may reveal the ulcer, but the track and the abscess may escape detection—a mistake which will render all treatment directed toward the cure of the ulcer futile. There may be several ulcers, only one of which has a fistula connected with it.

A fistula may heal spontaneously or after very slight stimulation, but such cases are very rare. Setting them aside, we are brought to the question which will often be asked by the patient, and which the surgeon may not always be able to answer to his own satisfaction, viz.,—whether or not it is always best, or even safe, to attempt a cure. In certain cases of Bright's disease, cancer, cardiac and hepatic affections, etc., all surgical interference may be plainly contraindicated; but the question is most apt to arise in connection with tuberculosis. Personally I always operate on tuberculous fistulæ if I believe the disease is not too extensive to permit of healing. No cautious practitioner would think of operating on an old case of disease which was quiescent and causing little trouble, in a person suffering from very advanced or rapidly advancing lung trouble. Cough, when violent and frequent, is a decided contraindication, interfering, as it most certainly does, with the healing of the wound. The sphincters should be interfered with as little as possible, for they are apt to be weak at the best; and the general health of the patient must in no way be impaired by the confinement necessary, after an operation, to secure healing of the wound. When the fistula is of recent origin, and, as is most often the case, attended by a good deal of undermining of the skin and profuse discharge, much may be done for the patient's relief, and in the majority of cases a cure can be established without any but good results as regards the lungs.

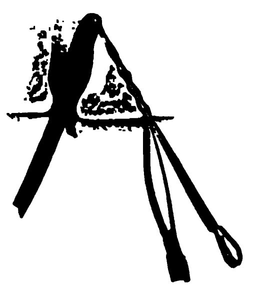
FIG. 230.—Operation for Fistula with Gorget. (Bernard and Huette.)

The prevailing idea that in order to cure a fistula it is necessary to divide the sphincter muscle, is often carried to a harmful extreme. Many of them may be cured by much simpler means, and many of them cannot be cured even by this one. There is, in fact, no rule which applies to all cases. Many sinuses in this part of the body are curable by the well-known means which are used in general surgery—free drainage and stimulation. Injections of iodine or nitrate of silver, the application of nitrate of silver fused on a probe, or of strong carbolic acid, the introduction of a fine sea-tangle tent, of a drainage tube or of a galvano-cautery wire, may any of them prove to be effectual curative agencies, but they are so more often in cases of superficial fistulæ which do not communicate with the bowel than in the deeper ones. In complete fistulæ, when not too deep, the best operation is that of incision with the knife. The mode of procedure in this operation, as well as that of employing the gorget or large wooden director to cut upon, which is often of great advantage, is shown in Fig. 230.

When no internal opening can be found, but the mucous membrane feels undermined, and the probe can be felt by the finger in the rectum, separated only by a thin layer of mucous membrane, it is a good plan to force an internal opening and treat the fistula as though it were complete. When there are two internal openings, both should be included in one incision. When, after the incision, the diseased integument is found to overlap the cut and fall into it, it should be cut away, and in old tracks the healing may be hastened many days by thoroughly scraping out the lardaceous wall with the handle of the scalpel, or by scarifying it in several places so that a healthy reparative action may be set up. Where the fistulous tracks exist in great numbers—twenty or thirty in some cases—it may be advisable to do two or three operations at intervals, rather than attempt, at a single sitting, more than the patient's strength is able to bear. In such cases there will generally be found two or three tracks which are primary, the others being merely offshoots from these, and each main track with its branches may be divided in one operation.

Fistulæ of the blind internal variety can only be dealt with rationally by incision.

FISSURE AND ULCERATION.—The many different varieties of non-malignant ulcers which are met with at the anus and within the rectum may best be classified in the following groups: simple, dysenteric, tuberculous, venereal, and rodent.

Simple ulcers are always of traumatic origin, and the most frequent injury to which the rectum is subject is, perhaps, that arising from the passage of hardened fæces. From this cause alone, or partly also, in some cases, by reason of the fact that they protrude from the anal orifice, the hemorrhoidal tumors may become ulcerated for a considerable extent. From this cause also a fissure is often produced within the grasp of the sphincter. Another frequent cause of injury is the presence of foreign bodies, either fish bones, date stones, etc., which have been swallowed; or larger substances which have been introduced *per anum*. An ulcer of the rectum is often caused by surgical interference, such as operations upon hemorrhoids or fistulæ, or unsuitable applications to fissures or a prolapse; and, in women, extensive ulceration and subsequent stricture may be caused by bruising the rectum between the head of the fœtus and the sacrum, in parturition.

An injury due to some of the causes already mentioned may, in certain persons, and when located at the verge of the anus, assume the characters of an affection which has been elevated into a separate class, and is known as fissure, or irritable ulcer. The irritable ulcer differs in no respect from other simple ulcers in the same locality, except in the fact of its irritability. There is nothing peculiar in the ulcer itself. It may be due to a slight rent in the mucous membrane from hard fæces; to a congenital narrowness of the anal orifice and a naturally over-powerful sphincter; to the irritation of a leucorrhœal discharge in women; to an herpetic vesicle; or to the venereal sore which it so strongly resembles, the soft chancre. Any sore which is fairly in the grasp of the external sphincter is apt to become an irritable or painful one; and a fissure may be painless at one time and painful at another in the same person; or painless in one person and painful in another. An ulcer associated with contracture, spasm, irritability, pain, and sometimes even with actual hypertrophy of the sphincter, is what is known properly as an irritable one; but a fissure may be present without exciting any of these symptoms.

These ulcers are generally situated at the posterior commissure, but they may be found anywhere on the anal circumference. They are generally single, but there may be two or three, more especially when they are of venereal origin. They are more common in women than in men, because constipation is more common in the former and because the skin is more delicate. They are confined to no age and are by no means relatively rare in infants. They are generally oval in shape with the long axis vertical, and involve both skin and mucous membrane, being situated just at the junction of the two. In some cases they have the appearance of a simple erosion, in others that of an old ulcer with grayish base and indurated edges which has involved the thickness of the mucous membrane and has extended fairly down to the muscle beneath. In the majority of cases they are not attended by suppuration or the discharge of pus, but they are apt to bleed a

little on slight provocation. They are often attended by small polypi attached near their upper end, or on the opposite side of the bowel, the presence of which may counteract all curative measures directed to the fissure alone.

The ulceration which results from a surgical operation or from a foreign body is easily recognized. Those which result from acute and chronic eczema and from pruritus are generally due to the injury inflicted by the nails of the sufferer, and present no special characteristics. An eruption of herpes around the anus, similar to what is seen on the lips, may result, after rupture of the primary vesicles, in numerous small, superficial ulcers of a reddish color, secreting a little pus. These may coalesce at their edges and form a serpiginous sore. They must be carefully distinguished both from mucous patches and from soft chancres.

From what has been said of the etiology of these simple ulcers, it is plain that they must present many variations in appearance; yet the diagnosis of each from the other, and of the whole class from those which are to follow, will not generally be found difficult if proper attention be given to the history, the appearance of the lesion, and its course. The disease is generally of a healthy type, and tends to self-limitation and spontaneous cure, rather than to increase. The ulcerative action is generally superficial, and tends to spread on the surface rather than in depth. The ulcer itself is generally surrounded by the signs of reparative action, and with proper care will undergo cicatrization, the result of which, when the ulcer has a large area, will be a stricture of the rectum.

In dysenteric ulceration the diseased portion of the bowel becomes infiltrated with fibrinous exudation, and, as a result of the pressure which this exercises, it undergoes necrosis and sloughs. There results a loss of substance, and if this is superficial, the mucous membrane may regain its former state; but if it is deep, the usual cicatrix is produced, and this, when of sufficient extent, will cause stricture. The stricture arising from this form of ulceration is sometimes very extensive.

The characters by which tuberculous ulceration may be recognized are the following: a pale red surface, covered with a small quantity of serum but devoid of healthy granulations and having a varnished appearance; the absence of surrounding inflammation; a tendency to spread in depth rather than on the surface; the absence of any marked pain; the regular outline ending abruptly in healthy skin; the chronicity of the disease; and the utter failure of all treatment to arrest its course. The diagnosis may be confirmed by the microscope. A tuberculous ulcer starting in the rectum may end in perforation and fistula—a fistula with large internal opening,—and, as a matter of course, the usual operation in such a case would be followed only by disappointment. Such an ulcer has also been known to cause sudden death from hemorrhage. The treatment should either be simply palliative, or else should aim at the complete removal of the tuberculous deposit, either with the cautery or with the knife.

Under the title of *esthiomène* (lupus exedens of the ano-vulvar region) a number of phagedenic ulcerations, complicated with more or less hypertrophy of the nature of elephantiasis, have been described, and thus much confusion has been caused. The term should be dropped from our nomenclature as having no definite meaning. The ulceration which is subsequently attended by so much hypertrophy commonly starts from the external organs of generation in the female, and invades the anus, rectum, and vagina secondarily. It is almost never seen in men. Its favorite starting-point is the perineum, and it may be superficial or perforating, and may produce great loss of tissue, turning the rectum and vagina into one cavity. In the late stage other ulcers are apt to appear higher up, causing diarrhœa and sometimes peritonitis; but whether these are simply follicular, or are due to further deposits of lupus, has not been determined. The ulcer is irregular in outline, with a granular base of a violet-red color, and there is a slight sanious discharge. The edges are but little elevated, and are not undermined, and there is more or less hypertrophy of the surrounding tissue, and this, in some cases, is exceedingly well marked. The ulcer may cicatrize in part, the cicatrix being thin and white, and at the same time the ulcerative process will be found to extend in the opposite direction. At a little distance from the ulcer there is often a pathognomonic appearance of slightly reddish, hard nodules of tuberculous lupus, separated from the primary sore by healthy skin. With this amount of disease the constitutional disturbance is often not sufficient to confine the patient to the house.

The diagnosis is not generally difficult, although the disease may be confounded with cancer, or with phagedenic chancroid, or with elephantiasis accompanied by secondary ulceration. It is best distinguished from cancer by the cicatricial bands which it leaves behind in its ineffectual attempts at healing, and from chancroid by the surrounding tubercles, which in lupus develop in the thickness of the derma and ulcerate secondarily, while the ulcers which surround a chancroid are ulcerous from the first, being due to secondary inoculation. The duration of the disease is indefinite, and it seldom leads to fatal results. It is best treated by destructive cauterization and *raclage*.

There are several varieties of ulceration of the rectum and anus of venereal origin. Without attempting to decide upon the specific character of the inflammation which may follow the contact of the gonorrhœal discharge, I may properly call attention to the severity of that inflammation and to the fact that it may cause ulceration and probably subsequent stricture. During the height of the disease the rectum is hot, red, swollen, and granular, and there is an abundant purulent discharge issuing in clots. The irritation of this may cause erosions and fissures which may reach a considerable size, or a previously existing fissure may become inoculated in this way and may increase in extent.

One of the most frequent of all the superficial ulcerations at the anus is the chancroid. It is much more common in females than in males, constituting one in nine of all cases of chancroids in the former, and one in four hundred and forty-five in the latter. To account for this greater relative frequency it is only necessary to remember the frequency of accidental contact of the male organ in coition, and the facility of auto-inoculation due to the proximity of the vulva. These ulcers are seen either on the skin around the anal orifice or just within the canal, and show a decided tendency not to pass beyond the internal sphincter. They may be single or multiple, and may be situated at any point in the anal circumference, or may completely surround it. When several such ulcers have coalesced the suffering may be severe. The sores have the same characters as those which they present in other parts of the body, and the class of women upon whom they are found is an aid to diagnosis. If any suspicion of the real character of these sores exists, the test of auto-inoculation may be tried. Ulcers of this variety tend to spontaneous cure if the parts are kept clean. In some cases, however, judicious cauterization may be found necessary. No matter how completely the ulcers may have involved the anus or the skin around it, they seldom leave any trace after healing. On the other hand, the cure may be delayed for months, and the sore may assume a chronic type due either to the coexistence of some other disease of the rectum, or to a syphilitic or scrofulous taint in the patient.

That a chancroid may extend into the rectum, cause great destruction, cicatrize, and leave a stricture, seems to be beyond doubt. That chancroid is, however, the most common cause of those grave strictures which are so often met with in women who have had syphilis, and which are generally known as "syphilitic," is by no means proved and is no longer generally accepted. That many of them are not due to this cause is rendered certain by the fact that they are often found in women beyond the suspicion of chancroid, and they are often developed late in the course of true syphilis, are not preceded by any ulceration near the anus, where chancroids are usually located, and

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do have their starting point in an ulceration well above the internal sphincter.

True chancre at the anus is not very uncommon. Probably many more of them exist than are ever diagnosticated, because they cause so little local trouble. True chancre within the rectum is so rare as to be almost unknown, and the difficulties surrounding its diagnosis are very great. The appearances which it presents would scarcely be conclusive, and the absence of any other primary sore would need to be absolutely proved—something which in women would be a very difficult thing to do. Typical cases have, however, been reported (Hartley).

One of the secondary manifestations of syphilis is to be looked for at the anus and rectum, viz., the mucous patch, not an infrequent sign in the former locality, and one liable to take on ulceration from local irritation. Generally, however, these mucous patches are devoid of symptoms and disappear without treatment, or with simple attention to cleanliness and the use of an astringent wash.

Well-marked cases of tertiary syphilitic ulceration in the rectum, such as are seen in the mouth and throat, are seldom mentioned; and yet that they may exist and may cause extensive destruction is probable from analogy. Clinically there is an entire absence of authentic and well-reported cases.

Rodent ulcer is a rare disease at the anus, but it has been occasionally seen. It is found by preference just at the verge and extending into the canal from this point. It has the same characters as when seen on the face.

Not only is ulceration the most common cause of stricture, but the latter is generally a cause of the former by its obstructive action, and by reason of the changes which it causes in the nutrition of the parts. At first there are dilatation of the rectal pouch and hypertrophy of its walls above the seat of the disease, due to the effort to overcome the obstruction. In this way the coats may become of double their natural thickness. Next, an ulcerative action is set up in the mucous membrane, which begins as a simple congestion, and advances to complete destruction of the tissue over, perhaps, the whole circumference of the bowel, and for several inches above the stricture. As a result, the muscular layer may be entirely denuded, and even perforated, at a considerable distance above the seat of the disease. Finally, the gangrene which sometimes follows the continued fevers and is particularly liable to affect the female genitals, and the more severe forms of abscess may, by their extensive sloughing, end in the production of large ulcerated surfaces.

The symptoms of ulceration are quite characteristic. In simple fissure the chief one is the peculiar pain, which may be constant, but is always increased by defecation. The latter act itself may not be particularly painful, but afterward, sometimes almost immediately, sometimes after a short interval, the characteristic suffering begins, and may last in mild cases an hour or two, or in severe ones nearly all of the twenty-four hours. The pain is described as dull, gnawing, and aching, rather than lancinating, and will often extend into the loins and thighs. Bleeding at stool is also a common symptom, and the extent of the fissure is no indication of the amount of suffering it may cause. The element upon which the pain directly depends is probably the exposure of nerve filaments. Ulceration within the rectum is also attended by a train of symptoms sufficiently characteristic to render its existence extremely probable when these occur. They are morning diarrhœa of a peculiar kind, the desire for a passage coming on as soon as the patient awakes, and the stools being at first mucous, and finally containing fæces, mixed, perhaps, with blood. After a couple of hours these stools cease for the day, and nothing more is felt except occasional pain and a constant uneasiness in the part. As the disease increases, the diarrhœa will return in the evening, the discharge of blood and mucus will increase in quantity, and the pain will become constant and very exhausting. It is scarcely necessary to call attention to the extreme gravity of this condition, or to the certainty with which, if untreated, and sometimes in spite of the best of treatment, it will end either fatally or in stricture. The picture is, unfortunately, only too familiar, and a case of ulceration within the rectum is perhaps one which calls for as much skill in treatment and yields as poor results as anything in the range of surgery.

The diagnosis of the presence of ulceration is not difficult if sufficient pains are taken to ascertain the truth. No ulcer within four inches of the anus is beyond the reach of actual touch and vision, and none need therefore escape detection. The rule is simple. If the sore cannot be felt by digital examination, ether should be given, the anus dilated, and a thorough speculum examination made of every part. In every case the history must be taken into consideration as well as the appearance of the sore.

The treatment of fissure should in the first place be preventive. In those persons in whom the skin is unusually sensitive and liable to crack, there is nothing better than daily ablutions with cold water and the avoidance of anything which may tend to irritate the anus—such, for example, as the use of printed or rough paper after defecation. A fissure may often be cured by applications of weak solutions of nitrate of silver, Goulard's liniment on a pledget of lint, an ointment of oxide of mercury (ʒ ss. to ℥ i.), or the introduction of a well-oiled bougie. I seldom find a fissure which cannot be cured by this line of treatment and without the necessity of stretching the sphincter; but with these local measures must be combined the greatest possible amount of rest and the daily administration of a mild laxative to secure an easy passage. If the pain be severe, it is a good plan to have the evacuation late at night just before retiring, and then to use an ointment of belladonna freely. Instead of stretching the sphincter, which involves the previous administration of ether, many cases may be cured by drawing a sharp knife over the base of the ulcer, and cutting sufficiently deep to divide those fibres of the sphincter which are exposed. If a polypus be present it must be removed, else no line of treatment will be of any avail.

The treatment of ulceration within the rectum is a much more difficult matter, but the principles involved are the same. In both we give the ulcer rest and try to assist nature in her own methods by warding off any irritation which may interfere with the work of repair. The general treatment consists of absolute rest in bed and the taking of fluid diet. Cod-liver oil may also be given, when well borne, as a laxative and tonic. The local treatment consists in various applications. Suppositories serve a good purpose and may contain any drug desired—tannin, iodoform, bismuth, opium, belladonna, etc. The practice of introducing local remedies in this form has many advantages over that of applying them by means of a speculum, for the mere introduction of a speculum two or three times a week is apt to do more harm than the remedies will do good. Certain good results may be gained by applications made in the form of enemata, especially when the disease is high up. Three pints of water may be thrown into the sigmoid flexure through a long rectal tube, and parts may be reached in this way which cannot be so by any other method. The drug from which the best results may be expected is nitrate of silver in the strength of from twenty to forty grains to three pints of water. The application of pure nitric or carbolic acid to an ulcer within the rectum is often followed by immediate reparative action. It is especially indicated in syphilitic disease which has failed to respond to constitutional treatment.

STRICTURE.—Stricture of the rectum may be congenital or acquired. The congenital will be referred to under the head of Malformations. Acquired strictures may be divided into: (1) those due to pressure from outside the bowel; (2) spasmodic; (3) inflammatory; (4) cancerous.

A tumor of any kind in the pelvis will not infrequently so press upon the rectum as to obstruct its calibre. A pelvic inflammation in women may be accompanied by an amount of exudation which shall almost completely occlude the rectum. Medical literature is full of such cases, and here it is only necessary to refer to them.

Much has been written in the past upon the question of spasmodic stricture, but the condition is looked upon

by the best authorities with great doubt. Spasmodic contraction or stricture of the external sphincter muscle is not an unusual condition, but spasmodic contraction of the canal above that point has always been a matter of belief and of assertion rather than of demonstration. It is perhaps too much to say that spasmodic stricture never exists; but a well-marked contraction within reach of the finger, which can be plainly detected by an ordinary digital examination, and which disappears under anæsthesia, is rarely seen.

Among the inflammatory strictures may be classed the dysenteric and the traumatic. Dysenteric ulceration has already been spoken of, and strictures due to this cause are often very extensive and not infrequently multiple. Proctitis, whether acute or chronic, when sufficiently severe and attended by sufficient changes in the coats of the bowel, causes stricture and *is the most frequent cause of the condition*, and a simple traumatism may lead to this result, either by causing ulceration and cicatrization or by exciting a chronic inflammation in the submucous connective tissue. Among these traumatisms may be enumerated, surgical operations, foreign bodies, kicks, and falls, and the injury produced by the head of the fœtus at birth.

A stricture of the rectum of venereal origin is rather a matter of surmise and supposed analogy with what is observed in other parts of the body than of actual demonstration. The venereal ulcerations which, by subsequent cicatrization, are supposed to be capable of producing stricture have already been referred to. They are the chancroid and the later syphilitic ulcers. As for the old time-honored "syphilitic stricture of the rectum," modern pathology teaches that it is a simple chronic hypertrophic proctitis entirely independent of syphilis and due to any one of the various causes which may excite a simple inflammation in the wall of the bowel. The process usually begins in the submucosa, the ulceration and hypertrophy being the natural sequences.

The first step toward establishing the diagnosis of stricture of the rectum is to make an examination with the finger, and, as the great majority of strictures are confined to the lower part of the rectum, this is in itself generally sufficient. It is the best, safest, and least painful of all the means of diagnosis when properly executed, and yet it may be the immediate cause of death when roughly practised. Where the seat of the disease is within reach of the finger, all can be learned in this way, as a rule, that can be learned in any other, and nothing is to be gained by a painful speculum examination or by the use of a bougie.

When a stricture is situated high up in the rectum or in the sigmoid flexure, the confidence in diagnosis which comes from actual contact of the finger with the disease, is entirely lost when any other method of examining is employed. The search for a stricture in this locality must always be made with the greatest gentleness, and the result will often be negative. The attempt to decide the question by the use of bougies is altogether unsatisfactory, and by no means free from danger.

In certain cases information may be gained by the use of a long, cylindrical speculum, while the patient bends over a chair and strains to bring the parts into view; and it is worth remembering that a full inch may be gained in a digital examination by having the patient stand erect and strain down upon the finger. Fortunately, however, we are not limited to these means alone for a diagnosis. Most strictures in this part of the bowel are cancerous, their presence can be pretty accurately surmised from the general symptoms, and after a time they can be felt through the abdominal wall by careful palpation. If the diagnosis cannot be made in this way, and the symptoms justify it, there is but one means left, viz., to make a bimanual pelvic examination, the patient being under the influence of an anæsthetic. I know of no other way than this by which a stricture of the sigmoid flexure which cannot be felt by external manipulation can be certainly recognized.

The treatment of stricture of the rectum is both constitutional and local. The first question to be answered is as to the advisability of antisyphilitic treatment, and this may generally be answered in the negative. The practitioner who considers the great majority of strictures as syphilitic, and indiscriminately uses mercury and iodide of potassium, will be mistaken about as often as he who looks upon most of his cases as being cancerous, and, therefore, incurable.

There are various means by which the comfort of these patients may be increased without recourse to operative treatment. The most effectual of them will be found to be a careful regulation of the diet and rest in the horizontal attitude. The diet should be mostly fluid, and preferably milk. The bowels should move daily without straining. Should any medication be necessary to effect this, the mineral waters, Rochelle or Glauber's salts, or the compound licorice powder, will be amply sufficient. The general strength must be carefully supported, and in most cases in which it is well borne, cod-liver oil will serve a good purpose. When obstruction actually exists, much may be done in the way of general treatment before resorting to operation. Food should be almost absolutely suspended; opium should be given in large doses to allay peristalsis; and large poultices covering the abdomen will give great relief to suffering.

The various means of local treatment may be included under the four general heads of dilatation, division, colostomy, and extirpation. Dilatation may be either gradual or sudden, partial or complete. The use of bougies for gradual dilatation is an example of good practice originating in false ideas. The bougie is intended by its presence merely to excite absorption of organizable matter, and if the pressure be too great, too long-continued, or too frequently applied, it will cause more than sufficient irritation for this purpose, and will induce again the very condition it is intended to overcome. The rules which should guide the surgeon in this plan of treatment are now well understood and generally admitted. The dilatation should be intermittent and not constant. Attempts at constant dilatation by means of a bougie of any sort which shall remain permanently in place, generally result either in failure or in actual disaster. The dilatation should never be forced. A bougie should be chosen which will readily pass the stricture without stretching it, and if there be any doubt in the operator's mind about the proper size of the instrument to be used, one should be selected which is too small rather than too large. The instrument should never be passed oftener than on every alternate day, and twice a week may be better still. Little is gained by allowing it to remain for any length of time within the grasp of the stricture. In cases associated with much ulceration, dilatation by bougies is very apt to make matters worse instead of better; and, if they are used at all, they should be introduced with the greatest gentleness. As to the kind of bougie to be used, the softer and more flexible the better. When the stricture is within reach of the finger I invariably use my finger instead of a bougie. The patient may be greatly relieved by this method of dilatation. It must, however, always be continued indefinitely, for it does not cure the disease. A rectum which has once been the seat of an old stricture can never be made as it was before the disease by this or any other treatment. But though the measure may not be curative, it is perhaps as valuable a palliative as is at the command of the surgeon, and by it in suitable cases a patient may be kept in comfort for a period of years. It is applicable to all benign strictures, which are within reach from the anus; but when the disease is high up the procedure is not entirely free from danger.

The unsatisfactory results of dilatation, and the natural objection on the part of both patient and surgeon to the operation of colostomy, have given rise to another method of treatment which within a few years has assumed, deservedly, considerable prominence. This is the operation of proctotomy, or complete division of the stricture by a single deep incision. The operation may consist either in dividing the stricture alone, or the stricture and all

Anus and Rectum.

Rydygier's osteoplastic resection is shown in Fig. 231. By it the sacrum is turned to the right like a trap door and replaced after the operation. It certainly diminishes

FIG. 231.—Rydygier's Osteoplastic Resection. *a b*, Skin incision; *c d*, skin and sacral incision.

the deformity of the pelvis caused by the operation, but I have always thought it also increased the risk by rendering drainage less perfect.

The preliminary incisions, which are shown in the accompanying illustration, should be completed in a very short time. Until after the end of the sacrum has been removed no attention need be given to hemorrhage, except such as an assistant can give by making pressure with sponges. The bleeding will be mostly venous and not very severe; most of it will be found to have ceased by the time the bone has been removed.

Should there be a steady, persistent loss of blood from just under the stump of the sacrum, it will be from the sacral plexus of veins and it may be very annoying. It may be controlled by the pressure of an assistant's finger, or by a long pair of forceps slightly curved, or by a ligature passed under it with a needle; but tying in the usual way without a needle is often impossible. Attention is called to this little point because it is often a troublesome one. When the rectum has been removed the bleeding will generally be found to have ceased spontaneously, but much time and many ounces of blood may be lost in unsuccessful efforts to ligature these vessels, when the pressure of an assistant's finger would save both.

The pelvis is now freely opened and the operation may proceed.

First, the rectum should be isolated on each side by the finger. No cutting is necessary, as the gut will, to a certain extent, be found movable in its bed; but the finger cannot be passed completely under and around it on account of its size at this point, nor can it be drawn down at all on account of the firm attachments of the peritoneum and the meso-rectum. Any forcible attempt to drag it down at this stage of the operation is attended by great risk of rupture and consequent soiling of the wound, and all that should be attempted is gentle isolation on each side by separating it from its loose attachments with the finger, and discovering by touch the extent of the disease to be removed, which can generally be easily done by palpating the tube as it lies in the wound.

The next step in the procedure should be the deliberate opening of the peritoneal cavity as near as possible to the bottom of the recto-vesical or recto-vaginal fold. This is not always quickly accomplished, as the peritoneum is often covered by a considerable layer of connective tissue, and this may be nicked several times at various points before an entrance to the free peritoneal cavity is effected.

As the operator stands, unless he is ambidextrous, the most favorable point for opening into the cavity will be to the right of the gut, high up in the incision, as the gut is held over to the left side by an assistant. Care must be taken not to cut into the gut itself instead of into the subperitoneal connective tissue.

When once the peritoneum has been opened the right index finger may be passed into the cavity, hooked under the gut from right to left, and forced out of the peritoneum again on the left side of the gut and into the wound. In this way the upper rectum surrounded by its peritoneal layer, with its torn margin which went to make the *cul de sac*, comes into the wound and the gut is freed from one of its strongest suspensory ligaments.

The rectum is now held from coming down only by the meso-rectum, which binds it to the hollow of the sacrum, and, while gentle traction is made upon it with the index finger under it, as I have described, this last obstacle to its free descent may be cut away; but this, like every other step in the operation, should be done with precision and without violence.

It must be borne in mind that the nutrition of the upper end of the rectum after the removal of the diseased part will depend entirely upon vessels belonging to the

FIG. 232.—Posterior View of Rectum in Male.

...d Rectum.

tissue which is now being cut, and this nutrition should be interfered with as little as possible. The bowel should not be forcibly stripped off from the mesentery and connective tissue, leaving it a mere tube without sources of nourishment, but the mesentery should be divided with scissors at some little distance from its attached border so that any vessels coming from higher up and running parallel with the gut may be saved. Large veins may be divided between double ligatures to save blood.

The rectum has now been rendered freely movable and the time has come to resect or amputate the diseased portion. By palpating the gut from without, the upper limit of malignant disease can easily be determined. In the case of non-malignant ulceration it may often be necessary first to cut across the bowel above the strictured and thickened portion and then to remove successive sections till healthy mucous membrane is reached.

Before dividing the gut a ligature of gauze or an intestinal clamp should be applied above the point of section, and the wound should be carefully protected with packing of gauze. The cut ends should be carefully wiped with pledgets of gauze and dusted with iodoform, and the upper one should be entrusted to an assistant who, by covering it with gauze and holding it out of the way, will keep it from infecting the wound.

The lower end, held firmly by the operator, must then be rapidly dissected from its remaining anterior attachments and either cut off below the disease or removed down to the anus. In most cases of disease within reach of the finger by rectal examination, the latter step will be found necessary, and the attachments of the levator on both sides will have to be cut by scissors or knife. Bold and rapid dissection at this stage will save much bleeding.

During all this part of ... danger of infecting the w... divided bowel must be ... Up to this time compl... stage it is very diffic... depends most certainl... for fouling of the w... high fever, prolon... death rate.

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...sed during ... the male, ... patient had ... by the fre... ...raction. ... the urethral ... the necessary

FIG. 238.—Soft Polypus. (Esmarch.)

...w the ends together, or ... the stricture, it has been ...owel above of fæces, or in ...iled with the same during ... suturing of the ends of ...nt till a later period, and ...ificial anus, as shown in ...sequent plastic operation ...s devised and applied for ...own in the cuts (Figs. 236

...ne end by a colostomy in ...d a subsequent closure of ...ral wound has healed.

—Under this head may be ...ondylomata and the rarer ...gummata, fibromata, lipo... cysts.

...a benign tumor composed ...ments of the rectal wall; ...ucous membrane or of the ... The former is generally ...d the latter as hard or ...n Fig 238, and is often ...hildhood; the latter is ... the polypus of adults. ...se distinctions are of ...al value.

...s of the soft variety ... the size of a pigeon's ... to the touch, may ... under the finger with ...ing, and has a shaggy ...r surface. A micro...ination shows it to be ...long, fine, bifurcated ...ered with cylindrical ... The glandular or ad...olypus (Fig. 239) is ... size of a small plum, ... pear, and yet may ...ht of four pounds. ...ddish color; some...ften mammillated. ...dicle, generally to ...each of the finger; ...en the ileo cæcal ... hypertrophy of ...r the closed folli... polypus which is ... villi and the fol...under the various ...or, granular papil...

may know that he has as surely saved the life of such a patient as if he had removed a cancer, but the patient may not appreciate it, and may be tempted to compare his last state with his former, even though he may be cured of his disease and have gained greatly in flesh and strength. Therefore it is always better to bring the upper end down to the site of the natural anus when it can be done without too much danger of sloughing.

This point having been decided and the gut having been fitted to the position it is to occupy, the toilet of the peri-

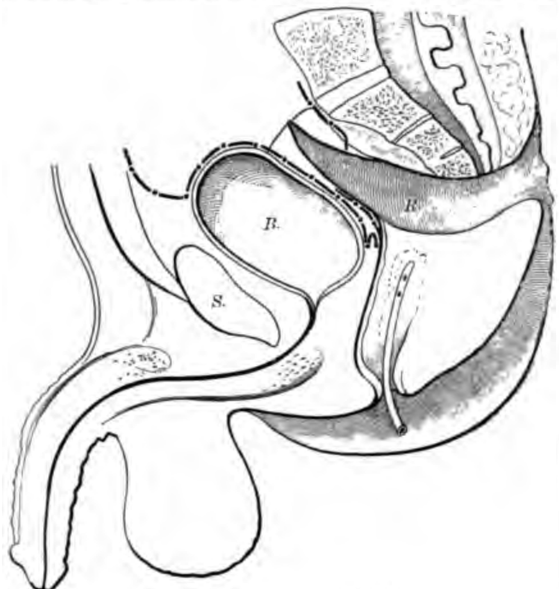


FIG. 234.—Rectum after Excision.

toneum may be attended to. This is much the same as in an ordinary laparotomy—hot douches with saline solution, or sponging till all fluids are removed from the deep portions of the wound.

Should the operator prefer to close the opening into the peritoneum by a separate catgut suture, this should next be done. It is not difficult to find the ragged margins of what is now left of the *cul-de-sac*, to run these margins together by a continuous suture from below upward, and finally to close the peritoneal cavity by stitching the edges of the torn peritoneum to the peritoneal layer of the bowel. I do not, however, consider this separate suture to be necessary.

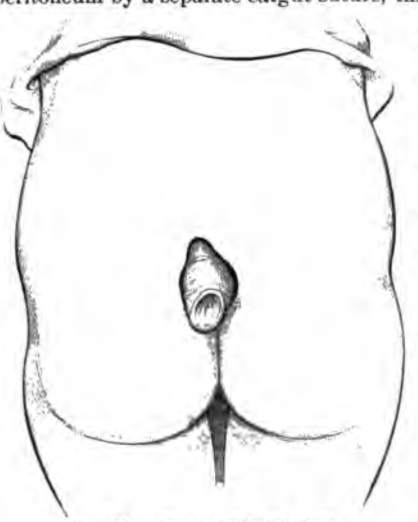


FIG. 164.—Sacral Artificial Anus.

The end of the gut should next be stitched to the skin at the point decided upon, and all parts of the wound should be drawn together as carefully as possible by deep and superficial sutures. The cavity left by removal of the rectum is too large, however, for perfect apposition of the parts or for union to be expected by first intention, and a drain of aseptic gauze should be passed down to its deeper parts. Free oozing will always take place from the bed from which the anal portion of the gut has been removed, and this can best be stopped by a few deep sutures in the final closure of the wound. In fact, it often cannot be stopped in any other way.

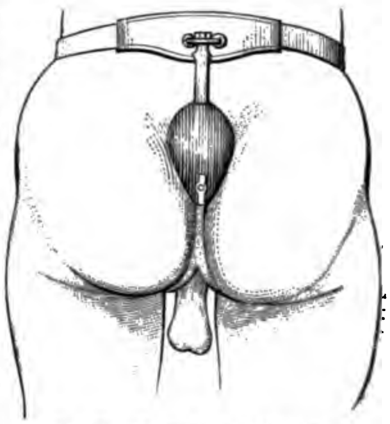


FIG. 236.—Truss for Sacral Anus.

Usually a sharp rise of temperature—to 102° or 102.5° F.—may be looked for, even in favorable cases, at the end of the second day, but in those that are to do well this will subside in a day or two spontaneously, and the patient will make an uninterrupted good recovery. A successful case may be sitting up at the end of two weeks, and several of my own have returned to their homes at the end of three.

The most careful end-to-end suturing of the gut after the removal of the disease should always be practised. If the anus has also been extirpated, then a very careful suturing of the end of the gut to the skin should be practised. The Murphy button is, generally speaking, not adapted to these cases for the reason that its successful use depends in great measure upon securing peritoneal approximation, and there is usually no peritoneum on the distal end of the gut after extirpation of the rectum.

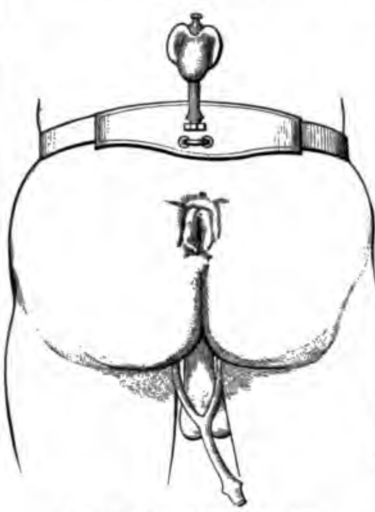


FIG. 237.—Truss for Sacral Anus.

When the suturing fails the vast wound will be found after two or three days to be full of fetid gas, pus, and fecal matter, and if the patient is fortunate enough to recover it is with a fecal fistula in addition to the anus provided by the operation.

In cases in which a fecal fistula has resulted at some point in the line of incision, secondary plastic operations are often successful. As a rule the gut itself must be dissected out and closed with Lembert's suture, and then the wound covered by suturing the skin and subcutaneous tissue. Closing the skin over the opening in the bowel without closing the opening in the bowel itself is seldom successful.

In avoiding fecal fistula trust must be placed entirely in a careful suturing of the cut ends, and the more carefully this suturing is done, and the more perfect the antiseptic precautions, the better chance there is of union without a large fecal abscess and subsequent fistula.

Anus and Rectum.

In amputation the upper end should be brought as near the site of the natural anus as possible; and if the sphincter has been left, the inside of the anus should be vivified in order to give some chance for union. Fecal fistula may, it is true, result in any case, but the main object of the operator should be to avoid this result, and the more thought he devotes to it, and the more perfect his antisepsis, the less likely it is to occur.

Sphincteric Action After Extirpation.—Many attempts have been made to secure this very desirable result, but most of them have proved ineffectual. As a rule there will be no sphincteric action after an amputation, and all hopes of sphincteric power after destruction of the muscle upon which alone it depends may as well be abandoned first as last. The twisting of the end of the gut before suturing it to the skin may do something, and so may an opening in the substance of the glutæus maximus muscle to which the end of the gut is sutured, but it is best not to hope for much from these expedients. The main thing to be hoped for is the avoidance of any contamination of the wound with fecal matter, and I can only say with regard to my own practice that I now generally expect a patient to recover from the operation of extirpation of the rectum, and that by careful attention to all the details of antisepsis and careful suturing of theend of the gut I generally manage to avoid the large suppurating cavities full of fecal matter which were formerly the chief cause of death after my own operations.

Many complications may arise during an operation for extirpation of the rectum. One of the most awkward I have ever personally encountered was to find a rectum absolutely devoid of mesentery and bound immovably to the hollow of the sacrum. All attempts to get it loose and bring it down resulted merely in stripping up one of the longitudinal bands of muscular fibres, and in the end I held in my hand six inches of stripped and injured gut which was entirely without any source of nutrition. As I was about to abandon the operation and turn the patient over for a left inguinal colostomy, it occurred to me to make use of a loop of large gut—probably the upper freely movable part of the sigmoid—which during a great part of the time had been hanging freely in the field and occasionally getting in the way. This was drawn into the incision and stitched to the edges in much the same manner as would be done in ordinary colostomy. It was then opened and the section between this opening and the end irrigated. Finally, the useless end of the gut was also stitched to the incision in the expectation that it would slough and come away, as it did. The man made a rapid and uneventful recovery.

Another complication, though not a frequent one, may be found in the consolidation of all the perirectal tissue by inflammatory changes, in cases of old, non-malignant ulceration and stricture. Under these circumstances the isolation of the rectum may be a matter of the greatest difficulty, and beyond the powers of the inexperienced operator.

Such in brief is the operation for extirpation of the cancerous or strictured and ulcerated rectum. The most casual reader will at once be struck by the fact that it is an operation of absolute precision, very different in character from the old one through the perineum, in which a more or less blind plunge was made into the pelvis for a piece of the rectum, and in which the loss of blood depended almost entirely on the speed with which the operator did his work.

The operation described may be done by an experienced man in about forty-five minutes, and the resulting mortality will depend much more on keeping fecal matter and other intestinal contents out of the wound, both during the operation and during the first days of healing, than upon the amount of shock.

My own first statistics showed the full death rate of thirty per cent., but by attention to the details given above this has gradually been reduced until, at this time of writing, I have had no death in the last seventeen cases.

A wound into the vagina, though always to be avoided when possible, may often be necessary in order fully to remove the disease. Such a fistula may be closed during the operation. A wound of the urethra in the male, when slight, is to be treated as though the patient had submitted to an external urethrotomy, viz., by the frequent passage of the sound to prevent contraction.

When a large piece has been taken from the urethral wall, a permanent recto-urethral fistula is the necessary result, and the danger of fatal inflammatory action is greatly increased from the presence of the urine in the rectal wound. Wounds of the peritoneum may or may not be sutured with catgut, as the operator prefers. As for the cases reported by Nussbaum and others, in which the whole neck of the bladder, the greater part of the prostate, and the seminal vesicles have been removed, and the patients have lived for years in comfort, they are merely curiosities of literature.

FIG. 238.—Soft Polypus. (Esmarch.)

In certain cases in which, from the extent of rectum removed, it is impossible to draw the ends together, or in which, from the tightness of the stricture, it has been found impossible to empty the bowel above of fæces, or in which the wound has become soiled with the same during operation, Kraske postpones the suturing of the ends of the gut at the posterior segment till a later period, and forms a provisional sacral artificial anus, as shown in Figs. 234, 235. For this a subsequent plastic operation is necessary. Hochenegg has devised and applied for use in these cases the truss shown in the cuts (Figs. 236 and 237).

Schede accomplishes the same end by a colostomy in the groin after the resection, and a subsequent closure of the artificial anus when the sacral wound has healed.

NON-MALIGNANT GROWTHS.—Under this head may be included polypi, vegetations, condylomata and the rarer examples of benign fungus, gummata, fibromata, lipomata, and the various forms of cysts.

A polypus may be defined as a benign tumor composed of one or more of the normal elements of the rectal wall; an hypertrophy either of the mucous membrane or of the submucous connective tissue. The former is generally spoken of as soft or villous, and the latter as hard or fibrous. The former is shown in Fig 238, and is often spoken of as the polypus of childhood; the latter is known as the polypus of adults, though these distinctions are of little practical value.

FIG. 239.—Glandular Polypus. (Esmarch.)

A polypus of the soft variety may reach the size of a pigeon's egg, is soft to the touch, may break down under the finger with rough handling, and has a shaggy or cauliflower surface. A microscopic examination shows it to be composed of long, fine, bifurcated papillæ, covered with cylindrical epithelium. The glandular or adenomatous polypus (Fig. 239) is generally the size of a small plum, rarely that of a pear, and yet may reach a weight of four pounds. It is vascular, and therefore of reddish color; sometimes smooth on the surface, but often mammillated, like a strawberry; attached by a pedicle, generally to the posterior wall at a point within reach of the finger; and may be found anywhere between the ileo-cæcal valve and the anus. It is due to an hypertrophy of either the follicles of Lieberkühn or the closed follicles. There is another variety of polypus which is formed by an hypertrophy of both the villi and the follicles of Lieberkühn, and is known under the various names of villous polypus, villous tumor, granular papil-

loma, and "peculiar bleeding tumor." These tumors are very rare, have the feel of a large warty polypus, with cauliflower surface, are of red color, bleed easily when touched, and are of relatively slow growth. They adhere to the rectum by a pedicle, sometimes composed chiefly of mucous membrane, and at other times large, short, and fleshy. The pedicle may be absent and the growth will vary in structure according to the proportions of its different elements. It may reach the size of an orange, is found only in adults, and the symptoms are the same as those caused by other polypi.

The hard or fibrous polypus (sarcomatous polypus), which is composed primarily of the elements of the submucous connective tissue, is much rarer than the soft variety, and is most commonly found in adults, in whom it may be single or multiple. It is composed chiefly of fibrous tissue, and resembles the uterine fibroid; but it may contain both muscular and glandular elements. These polypi vary greatly in the degree of hardness to the touch, according to their composition and turgescence. They may creak under the knife on section and look very much like hypertrophied and œdematous skin; or they may resemble the better known nasal polypus in composition. When they are seen in the rectum before removal the surface is generally red from vascularity; but after removal they are pale and generally smooth, though sometimes uneven and irregular in surface and covered with hypertrophied papillæ. The mucous membrane is generally easily stripped off, unless there has been local inflammatory action, in which case it may be firmly attached and have lost its natural appearance. The vascular supply is abundant, both in the substance and on the surface of the tumor. The pedicle is generally slight, and is formed mechanically by the traction of the growth. The tumor is benign in character, and when once removed does not generally return, although cases of recurrence at or near the same point are not unknown.

A rectal polypus may exist many years and give no signs of its presence. The two chief symptoms which it is apt to excite are hemorrhage and discharge. The former may be of daily occurrence, or may be present only at long intervals, and it may vary in amount from a few drops to a quantity which shall cause grave disturbance and alarm. When the mucous membrane covering the tumor has once become ulcerated, the bleeding will be frequent and the discharge more or less fetid. When the tumor is so high and the pedicle so short as to be beyond the grasp of the sphincter, there will be little or no pain; but after prolapse once begins to occur, the suffering at each act of defecation may be extreme. The sphincter may become dilated and relaxed, or if it remain strong it may work a spontaneous cure by strangulating the pedicle. The discharge is sometimes profuse and constant, escaping not only at the times of defecation, but at frequent intervals between, and being of an exceedingly fetid character. This by its irritation may set up secondary troubles—congestion of the mucous membrane, erosions around the anus, vegetations, diarrhœa, and tenesmus; and joined with the loss of blood the condition may be mistaken for extensive ulceration or malignant disease.

The treatment is generally simple. When the pedicle is long and slender the tumor may as a rule be safely twisted off, but it is better to apply a ligature. There are two dangers to be considered: the first is that the pedicle may contain large vessels, and the other is that it may contain peritoneum. The extirpation of a polypus which came down from the sigmoid flexure and dragged the peritoneum with it has been followed by death. Should there be a large, fleshy pedicle it must be securely ligatured.

The anus and adjacent skin are often the seat of vegetations of a warty or papillomatous nature, due to a simple hypertrophy of the papillary layer of the skin. They are composed of the connective tissue, the epithelial covering, and the blood-vessels, which in their natural proportions and quantities make up the papillæ of the derma. These little tumors resemble ordinary warts. When one of them is isolated it is dry, but when several of them are united they become macerated in the secretion of the part; this secretion undergoing decomposition in the spaces between them, and then giving rise to inflammatory phenomena. The tumor then becomes moist and fetid, and all the adjacent parts become irritated. According to the number and size of the warts, the condition of the patient, the abundance of the secretions, and the irritation to which they are originally due, these vegetations take on various shapes, and hence have been described as cock's-combs, cauliflower excrescences, etc., but the fundamental structure of all of them is the same. They were formerly considered as proof positive of syphilis, and even of sodomy, and were so treated; but they have nothing to do with syphilis, and they owe their growth, in the first place, to a special predisposition to the formation of warts in the individual, and, in the second place, to the presence of some irritating cause acting on this particular part. Thus the discharge from any disease of the rectum or genitals may cause them to grow, and they may appear in persons apparently perfectly healthy and cleanly. Pregnancy has an undoubted influence on their production, and they may disappear spontaneously after delivery. They may appear at any age from infancy to adult life, though generally belonging to the latter. They may vary in size and quantity, from a single enlarged papilla to a mass weighing a pound. When they grow from one side of the intergluteal fold, and are large enough to press with their moistened surface upon the corresponding point on the opposite side, a second patch may be developed at the point of contact. Their development may be slow or rapid, and when they reach a large size the patient is troubled by the feeling of a foreign body, by a sanious and foul discharge, and by fresh erosions and superficial ulcers in adjacent parts. Great pain in defecation may be caused by a small wart just at the verge of the anus, and such a little tumor may cause all the symptoms characteristic of fissure. These warts may also spring entirely from the mucous membrane above the sphincter. There is little danger of mistaking a mass of such warts for a malignant growth, though they have been known to assume a semi malignant character, and to return frequently after removal. The most common error is to consider them as syphilitic condylomata, and indeed they may not always be easily distinguishable from the raised mucous patch or flat condyloma which is a manifestation of true syphilis. The two may exist simultaneously, the former caused by the irritation of the latter.

The surest, most rapid, and in every way most satisfactory method of curing these warts is simply to cut them off with the knife or scissors. The ligature is not always applicable, and cauterization is apt to do more than is necessary. The growths may, however, be induced to dry up and shrivel away by applications of powdered alum or tannin, and by washing with astringent lotions, such as Labarraque's solution.

The term condyloma has been applied to so many different growths around the anus that it has lost all definiteness. The variety of syphilitic mucous patch situated upon the skin near the anus, and known as condyloma lata, or vegetating condyloma, first manifests itself as a red spot, and by a slight effusion beneath the epidermis, which is soon rubbed off by friction, exposing a raw surface generally covered by a grayish pellicle. This surface is subsequently elevated by an upward growth, and by branching of the papillæ, with formation of connective tissue and dilatation of the blood-vessels. Where this process has reached a considerable extent, a cauliflower appearance is the result, and what was at first a simple mucous patch may become a large, pedunculated, warty growth surrounded by other vegetations which have sprung up around the original lesion, and which are due to the irritation of its presence.

The more general meaning of the word condyloma is, however, a non-syphilitic tumor composed of an hypertrophy of the skin around the anus, attached by a broad base, pinkish in color, soft, fleshy, glistening, moist.

aqueous solution of sulpho-ichthyolic acid and the aromatic, oily sulpho-compound contained in ichthyol. Dark brown in color, it contains 16.5 per cent. of sulphur and 4.5 per cent. of ammonium. It is decomposed by acids and strong alkalies, and possesses the peculiar property of rendering such substances as phenol, guaiacol, cresol, camphor, etc., freely soluble in water. These solutions are called "anytols" and promise to be valuable additions to our antiseptic materia medica. Koelzer used a 7.5-per-cent. aqueous solution of metacresol anytol (metacresol, forty per cent.) in erysipelas. By painting it on frequently over an area extending somewhat beyond the inflammation he obtained a good result in every case. These anytols, especially those of phenol and cresol, may be used in five to ten per-cent. dilution for disinfection of the hands or for vaginal or intra-uterine douches. They then have much the same effect as creolin.

Anytin itself is capable of setting up an active dermatitis, but diluted to ten per cent. it is very useful in chronic eczema, sunburn, and ivy poisoning. Like ichthyol, it will probably be used internally as an intestinal or respiratory antiseptic. It is stated to be directly antagonistic to the diphtheria bacillus.

W. A. Bastedo.

AORTA (Latin).—Greek, ἀορτή, from ἀείρειν, to lift, to carry; French, *aorte, grosse artère*; German, *Aorta, grosse Schlagader.*

SYNONYMS.—Arteria magna (Harvey); hæmal axis (Owen). Originally, in the plural, aortæ (ἀορταί), the bronchial tubes (Hippocrates).

DEFINITION.—The main trunk (single in mammals and birds, double in cephalopods and most reptiles, triple in the crustaceans) of the systemic arterial system,* by means of which the oxygenized blood is carried to all parts of the body.

EMBRYOLOGY.—According to Gibson, "the single median tube," which is seen at one stage in the development of the vascular apparatus, begins to pulsate before the appearance of either muscular or nervous elements. "The heart movements must be due to some as yet unknown indwelling property of the embryonic heart tissue." In the development of the embryo there are two primitive aortæ. These unite early, and to them four lateral pairs are successively added, and all develop into the artery seen at birth—the aorta and its branches.

ANATOMY.—The aorta, although the main arterial trunk, is at its commencement generally a little smaller than the pulmonary artery, but in the aged it is usually slightly larger than that vessel. Its position, like that of other arteries, is protected in proportion to its importance. It takes its origin from the upper part of the left ventricle, extending upward and to the left for a short distance; then curving over the root of the left lung, it descends in front of the spinal column, passing through the aortic opening, *hiatus aorticus*, which is in the middle line behind the diaphragm, and which also transmits the vena azygos major, the thoracic duct, and occasionally the left sympathetic nerve. The vessel descends to the left side of the fourth lumbar vertebra, where it terminates, dividing into the right and left common iliac arteries. In its course it gradually decreases in size from 28 to 17 mm., giving off at different points branches of varying calibre. Quain divides this artery into the *ascending aorta*, the part within the pericardium; the *arch*, that part extending backward from the pericardial limit to the spine at the lower margin of the fourth dorsal vertebra; the *descending thoracic aorta*, from this point to the diaphragm, and the *abdominal aorta*, the part below the diaphragm. This method of division is founded on the fact that the first part is intrapericardial and has its origin from the fetal aortic bulb; while the third part of that section, which was formerly known as the *arch*, does not differ in relation, direction, or origin from the rest of the descending portion. The older anatomists treated the arch as consisting of three parts—the ascending, transverse, and descending, and comprising that part of the artery found between its ventricular origin and the lower border of the fifth dorsal vertebra. This latter division seems far less logical than the former according to the reasons just given. The first parts of both the aorta and the pulmonary artery are regarded embryologically as parts of the heart.

ASCENDING AORTA.—The ascending aorta springs from the upper and fore part of the left ventricle on a level with the lower border of the third costal cartilage behind the left half of the sternum. It passes upward, forward, and to the right in a line with the heart's axis till it reaches the upper border of the sternum, at which point its direction changes and the arch begins. The ascending aorta measures about two inches or two inches and a quarter in length, and it curves upward, backward, and to the left. Just above its origin this part of the aorta shows externally three small dilatations of about the same size, known as the *sinuses of the aorta* or *sinuses of Valsalva*. One of these sinuses is anterior, the other two posterior. The anterior and left posterior give origin to the two coronary arteries of the heart. Opposite to these three sinuses are the semilunar valves. A cross section of the vessel at this point is rather triangular in form, while below the valves it is circular. At the commencement of the arch and along the right side of the ascending aorta there is generally found another bulging, the *great sinus of the aorta*. Now and then this sinus is not present. It is seen more distinctly in the aged. The fibrous pericardium embraces the whole length of the ascending aorta, while a tube of serous membrane extends up from the cardiac surface to invest this vessel together with the pulmonary artery, except where they are in contact with each other.

Relations.—At its commencement the ascending aorta is covered anteriorly by the pulmonary artery and the right auricular appendix. Higher up, the directions of these vessels diverge, the aorta passing forward and to the right and the pulmonary artery backward and to the left. At this point the aorta closely approaches the sternum, being separated from it, however, by the pericardium, the right pleura, the narrow part of the anterior mediastinum, the anterior edge of the right lung, besides a little fat and areolar tissue, as well as the remains of the thymus gland. Posteriorly are the left cardiac auricle and the right pulmonary artery. At its right are the right auricle and the superior vena cava. On the left is the main pulmonary artery.

Branches.—The ascending aorta has two branches only, the right and left coronary arteries. These vessels, relatively small, spring generally from that part of the vessel which is just above the free margin of the semilunar valves, in the upper part of the two sinuses of Valsalva, and they supply the heart. The right coronary artery is about the size of a crow's quill, while the left is somewhat larger.

Varieties.—The ascending aorta and pulmonary artery may be transposed, *i.e.*, the former may arise from the right ventricle and the pulmonary artery from the left. There may be a communication between these two arteries by abnormal openings. One may be wholly or partly obliterated, while the other serves as a passageway for the blood of both by means of communications between them. There is now and then seen one simple tube connected with a simple heart like that in fishes. Sometimes the coronary vessels arise by a common trunk, or at times from the same sinus of Valsalva. As many as four arteries have been observed, in which case the supplementary vessels are smaller than normal and play the part of branches of the main coronary trunk, near which they take their origin. An extra coronary has even had its origin in the pulmonary artery. When one of the arteries is unusually small, the other is correspondingly large and supplies a greater area, especially at the back of the heart.

ARCH OF THE AORTA.—The arch or transverse aorta begins at the upper margin of the second right costal cartilage at the right border of the sternum and arches around the trachea, in its course passing upward, backward, and to the left of the body of the fourth dorsal vertebra. At this point it passes downward, and at the

* Foster's Encyclopædic Medical Dictionary.

inferior margin of this vertebra the thoracic aorta begins. **The arch** at its superior border is generally about an inch **below** the upper margin of the sternum in the median **plane.**

Relations.—The arch of the aorta is situated in the superior **mediastinum.** and it is covered in front by the

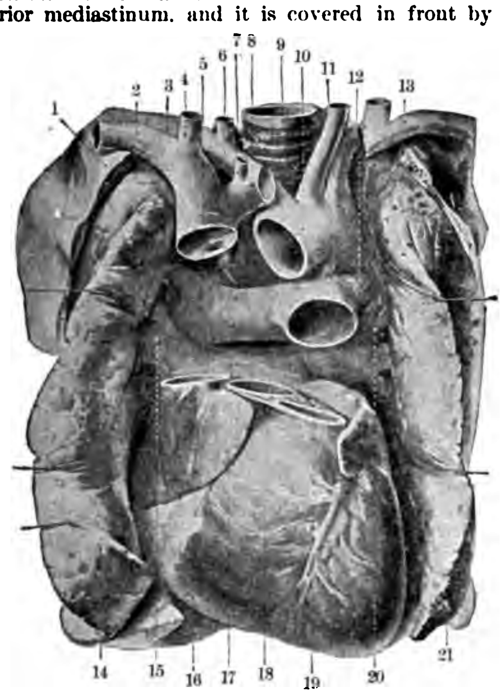


FIG. 240.—Anterior View of the Great Vessels of the Heart. (From His's "Handatlas der Anatomie des Menschen.") 1, First rib; 2, subclavian vein; 3, subclavian artery; 4, internal jugular vein; 5, right branch of pulmonary artery; 6, vena azygos; 7, inferior thyroid vein; 8, left innominate vein; 9, trachea; 10, arch of aorta; 11, ductus arteriosus; 12, left pulmonary artery; 13, subclavian vein; 14, right lung; 15, right pulmonary veins; 16, vena cava superior; 17, left atrium; 18, ascending aorta; 19, pulmonary artery; 20, left pulmonary veins; 21, left lung.

pleuræ and lungs, and the fatty remnant of the thymus **gland.** On the left it is crossed by the left pneumogastric **and phrenic** and the superior cardiac branches of the left

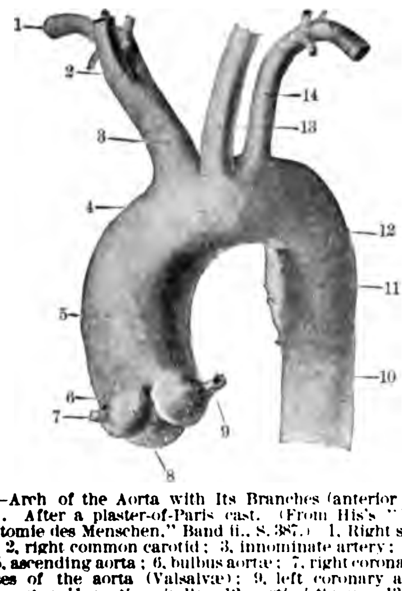


FIG. 241.—Arch of the Aorta with Its Branches (anterior and from the left). After a plaster-of-Paris cast. (From His's "Handatlas der Anatomie des Menschen." Band ii., S. 387.) 1, Right subclavian artery; 2, right common carotid; 3, innominate artery; 4, arch of aorta; 5, ascending aorta; 6, bulbus aortæ; 7, right coronary artery; 8, sinuses of the aorta (Valsalvæ); 9, left coronary artery; 10, thoracic aorta; 11, aortic spindle; 12, aortic isthmus; 13, left common carotid; 14, left subclavian artery.

sympathetic nerve and by the left superior intercostal vein, while the left recurrent laryngeal bends upward beneath it. Posteriorly and to the right lie the trachea, the deep cardiac plexus, the left recurrent laryngeal, the œsophagus, the thoracic duct, and the body of the fourth dorsal vertebra. The anterior part of the upper margin of the arch is in contact with the left innominate vein, and gives origin to the large arteries—innominate, left carotid, and left subclavian—which supply the head and upper limbs. The border is just above the left bronchus and the bifurcation of the pulmonary artery, and it is joined with the left branch of that vessel by a fibrous cord, representing the remains of the ductus arteriosus, which is connected with the aorta just beyond the origin of the left subclavian. Between the arch and the bifurcation of the pulmonary artery are found the superficial cardiac plexus and a few large bronchial lymphatic glands. To its inferior, anterior surface the fibrous pericardium is attached. After giving off its branches, the arch is reduced in size to some extent (23 mm.). There is often seen at that point where the ductus arteriosus is attached, a constricted part, which is called the *aortic isthmus.* The isthmus is far more marked in the fœtus from the expansion caused by the opening of the ductus arteriosus. Beyond comes a fusiform dilatation reaching to the thoracic aorta and called the *aortic spindle* of His.

FIG. 242.—View of the Abdominal Aorta. (From Joessel-Waldeyer: "Lehrbuch der Topographisch-Chirurgischen Anatomie.") 1, Right common carotid; 2, innominate artery; 3, right subclavian artery; 4, right lymphatic duct; 5, right innominate artery; 6, superior vena cava; 7, posterior intercostal glands; 8, vena azygos; 9, inferior vena cava; 10, right lumbar lymphatic duct; 11, left lumbar lymphatic duct; 12, receptaculum chyli; 13, thoracic duct; 14, posterior intercostal glands; 15, aorta; 16, left innominate vein; 17, left subclavian vein; 18, left subclavian artery; 19, mouth of thoracic duct; 20, internal jugular vein; 21, left common carotid.

Branches.—The aortic arch has three branches springing from its upper surface—the innominate or brachiocephalic artery, the left common carotid, and the left subclavian. The left carotid and the innominate arteries are generally nearer together than the left carotid and the left subclavian. These vessels supply the head, neck, upper extremities, and part of the thorax.

Varieties.—The upper limit of the aorta may vary as widely as two vertebræ. It is found in some subjects as high as the third dorsal vertebra, at the level of the top of the sternum, while in others it is as low as the fifth dorsal. Sometimes there is complete lateral transposition of the aortic arch and pulmonary artery together with the great veins and the divisions of the heart (*dextrocardia*). This abnormality may be confined to these parts or may embrace all the viscera (*situs inversus*). The aortic arch has been observed to be completely double. It has also been seen to pass to the right of the trachea and œsophagus instead of to the left, and to continue its downward course on the right side of the spine. In this

case the three branches have an arrangement the reverse of the usual one.

Variations in the number and position of the branches of the arch are frequent. There may be only one trunk, or there may be from one to six inclusive.

DESCENDING THORACIC AORTA.—At the termination of the arch, at the lower border of the fourth dorsal vertebra, the descending aorta begins and continues down along the spine to the fourth lumbar vertebra, where it divides into the two common iliac arteries. Its direction is not vertical, for as it rests against the spine it necessarily follows the spinal curves, being concave forward in the dorsal region and convex forward in the lumbar. As its commencement is to the left of the spine and its termination nearly in the median line, its general direction throughout its whole length is inward, this being more marked in its upper part. The lower limit of the thoracic aorta is the *hiatus aorticus* at the level of the diaphragm. This part of the aorta is from seven to eight inches long and is contained in the back part of the posterior mediastinum, where it rests against the spine. Its branches are small, and consequently its size is little di minished (from 23 to 21 mm.).

Branches.—The branches of the descending thoracic aorta, though numerous, are small. They are the pericardial, bronchial, œsophageal, posterior mediastinal, and intercostal.

Varieties.—Now and then an obliteration of the aorta at the point of junction of the arch and thoracic aorta is observed, just below the connection between the ductus arteriosus and the arch, known as coarctation of the thoracic aorta. This condition results in the establishment of the interesting collateral circulation which takes place. Not infrequently variations in the number and position of the branches of this section of the aorta are observed.

ABDOMINAL AORTA.—This name is given to the vessel between the diaphragm and its bifurcation into the two common iliac arteries. In relation to the spinal column it begins about the lower margin of the last dorsal vertebra and ends at a point about the middle of the fourth lumbar vertebra, most generally slightly to the left, sometimes almost exactly in the median line, at other times slightly to the right. This point almost corresponds to the level of a line drawn between the two iliac crests or to a point just below and to the left of the umbilicus. In length it is about five inches. As its branches are both numerous and large, its size rapidly diminishes. As mentioned before, its curve as it rests against the vertebræ has its convexity forward, being most prominent at the third lumbar vertebra, slightly above and to the left of the umbilicus.

Relations.—Anterior to the abdominal aorta are the lesser omentum and stomach, the solar plexus, splenic vein, pancreas, left renal vein, transverse duodenum, mesentery, aortic plexus, peritoneum, lymphatic vessels and glands, and dense areolar tissue; posterior to it are the bodies of the vertebræ and the left lumbar veins, the thoracic duct, and the receptaculum chyli. On the right are the inferior vena cava, right crus of the diaphragm, vena azygos major, thoracic duct, and right semilunar ganglion. On the left are the sympathetic nerve and the left semilunar ganglion.

Branches.—These may be classified under two heads: (1) Visceral—cœliac axis (gastric, hepatic, splenic), superior mesenteric, inferior mesenteric, suprarenal, renal, and spermatic or ovarian. (2) Parietal—phrenic, lumbar, and sacra media. The branches of the aorta mostly pass off at right angles.

Varieties.—Instances are known in which the aorta is divided by a septum for either a part or the whole of its course, so that two closely united tubes are the result. Sometimes this condition has a pathological foundation, at other times it is due to an embryological defect in the fusion of the double fetal aorta. The vessel has been known, as in certain quadrupeds, to divide up into an ascending and a descending branch, the former subdividing into three trunks to supply the head and upper extremities. The aorta may vary in position and extent. Its lower limit may vary to the depth of a lumbar vertebra, so that its bifurcation may take place at the third, or even higher, at the fifth. Its deviation from its normal position with reference to the vertebral column is generally due to pathological changes rather than to congenital causes. Quain speaks of two cases of a large pulmonary branch springing from the aorta very near the cœliac axis, which, after having passed upward through the œsophageal foramen in the diaphragm, separated into two branches and entered the lungs near their bases. Balfour, in writing of the simulation of aneurism by malposition of the aorta due to rickets, says: "In rickety chests the aorta may be so deflected, without any marked dilatation, as to make its pulsation visible either to the right or left of the sternum, and so to simulate an aneurism. It is of even greater consequence to have proof that in certain comparatively rare cases a similar abnormal pulsation may be due to a trifling divergence from the normal course of the vessel itself, apart from any marked change in the bony skeleton. But we must never forget that aortic aneurism may coexist with malformation of the thorax with or without scoliosis, and whatever may be the condition of the skeleton, any abnormal pulsation must be carefully considered from every point of view before we are able to give any definite opinion as to what it really is." Virchow has pointed out the relation of the reduction in size of the aorta to chlorosis, and he named the condition *aorta chlorotica.* Congenital stenosis of the aorta is seldom seen. Rosenbach has noted this condition found together with hypertrophy of the heart. It may cause sudden death, and when it is present, otherwise unimportant affections may assume a grave aspect, from sudden untoward cardiac symptoms. In congenital stenosis of the aortic system, a striking characteristic is the continuous subnormal temperature present in infectious diseases which normally show a high temperature. In women this condition is generally associated with infantile uterus and other signs of arrested development.

STRUCTURE.—The aorta is very strong and elastic and is enclosed, like most other arteries, in a sheath, which has more connective than yellow elastic tissue, so that, when cut, the vessel shrinks within the sheath. It is composed of three coats—(1) tunica intima; (2) tunica media; (3) tunica adventitia. The internal coat, smooth and offering but little, if any, resistance to the blood, consists of three layers: (*a*) Epithelial layer or arterial endothelium. This is made up chiefly of irregular, flat, polygonal cells with round or oval nuclei with nucleoli. (*b*) Subepithelial layer, which is well marked and consists of numerous anastomosing cells resting in a delicately fibrillated groundwork of connective tissue. There are, besides, elastic fibres which are in connection with the next layer. (*c*) Elastic layer, which forms the principal part of this inner coat. Sometimes this network assumes characteristics which have caused it to be designated as the "perforated" or "fenestrated" membrane of Henle. At times it is represented by a longitudinal network of fibres. The middle coat is muscular, consisting of bundles of plain muscle fibres, which are disposed circularly around the vessel, although not forming a complete ring. These fibres contract and relax, thus changing the calibre of the vessel. Elastic fibres are also found well developed in this tunic, and there is also considerable connective tissue. This coat is thicker than the corresponding coat in other arteries. It has also relatively more elastic tissue and less muscular tissue than is found in other arteries. The external coat consists of white connective tissue and elastic fibres. The connective-tissue bundles run chiefly diagonally around the vessel and connect it with its sheath. This is the strongest and densest coat.

Vessels and Nerves.—Both small arteries and veins ramify in the external coat of the aorta and are called *vasa vasorum.* They serve as nutrient vessels. Ranvier states that in health in the human subject they never penetrate to the middle coat. The inner coat is thought to be nourished by the blood circulating through it. Although the aorta is supplied by nerves, it is insensible when in a healthy condition. These nerves are chiefly non-medullated. The finer branches are distributed chiefly to the

Thus it will be seen that aphasia may be the result of conditions by which the patient is unable to part with the expressive equivalent of an idea which has been properly formed. The failure is not confined to words, but includes all modes of expression. Or it may be caused by any conditions that interfere with the reception of impulses or stimuli that enter into the genesis of ideas used in the construction of internal or external language. As movement in some form is requisite for the manifestation of all expressions, defect of this is the condition to which the term motor aphasia or aphasia of emission is applied.

In the second form of aphasia the sufferer is unable to adapt receptive communications and make them fit the idea represented by the verbal symbol, auditory or visual;—that is, he has lost the faculty of adapting the complement of the word to his own idea; it matters not whether these words be spoken or written, or communicated by some equivalent, such as music and pantomime. In a general way, this is aphasia of reception, or sensory aphasia.

Motor aphasia, or aphasia of emission, which was described by Broca as aphemia, and by many writers after him as ataxic aphasia, may be divided into as many forms as there are habitual avenues of externalizing thoughts. Ideas are usually exteriorized by spoken words, by written words, by symbols, and by pantomime. Thus we have aphasia of articulation, logaphasia; aphasia of writing, agraphia or logagraphia; asymbolia, and asemia. Aphasia of reception, or sensory aphasia, is also made up of a number of constituents, the two great divisions being auditory aphasia, or word deafness, and visual aphasia, or word blindness. Each form of aphasia admits in turn of further subdivision.

Aphasia may be classified as follows:

1. *True Aphasia.*—Aphasia of apperception. Due to lesion of any constituent of the speech region, the zone of language. It might be subdivided into (*a*) visual aphasia, due to lesion of the visual areas and centres; (*b*) auditory aphasia, due to lesion of the auditory areas and centre; (*c*) articulatory kinæsthetic aphasia, due to lesion of the centre in which are stored memories of the movements necessary to externalize the word by speech.

2. *Sensory Aphasia.*—Due to lesion of the central and peripheral sensory pathways leading to the zone of language.

3. *Motor Aphasia.*—Due to lesion of the motor pathways, over which the motor impulses travel in passing to the peripheral speech musculature.

4. *Compound Aphasia.*—Any combination of two or more of these.

5. *Associative or Transcortical Aphasia.*

The lesion may be:

(1) In the habitual pathway traversed by impulses going from the auditory to the visual area (the patient can hear a name, but cannot write it from hearing; cannot write it from dictation, he has paragraphia).

(2) It may be in the habitual pathway of impulses going from the visual area to the auditory area (the patient can see an object, but he cannot call up its name, because this requires the mediation of the auditory area).

(3) A lesion that interrupts the habitual pathway that impulses take when going from the auditory area to the seat of phonetic memories in Broca's convolution (the patient can hear, can interpret from hearing, but cannot talk correctly; paraphasia).

(4) The lesion may interrupt the pathway taken by impulses going from the visual area to the auditory area (the patient is dyslexic, paragraphic, and slightly paraphasic).

For purposes of convenience I shall adopt the following classification as a working one, and I desire to say at the outset that the word motor aphasia is never used synonymously in my own mind with the word ataxic aphasia; moreover, that the word motor is reserved for application to that form of aphasia which is anatomically characterized by lesion of Broca's convolution, solely because such usage has been consecrated by time. The images stored up in this centre are genetically sensory, the result of motion.

Motor aphasia.		1. Lesion of the kinæsthetic-articulatory centre, Broca's area (and probably of the associative fibres connecting them with the cortical motor areas in the Rolandic region), causing articulatory amnesia.
		2. Lesion of motor fibres which convey speech impulses: subcortical motor aphasia. Pure motor aphasia of Dejerine.
		3. Lesion of any part of the peripheral neuromuscular apparatus serving articulate expression: dysphasia, lallation, alallia.
Sensory Aphasia.	Auditory.	1. Lesion of the receptive cells constituting the auditory centre causing abolition of function, word deafness and its entailment.
		2. Lesion of the subcortical sensory tract: subcortical auditory aphasia; pure auditory aphasia of Dejerine.
	Visual.	1. Lesion of the receptive cells of the higher visual centre causing word amnesia, graphic and visual word blindness, and its entailment.
		2. Lesion of the subcortical tract and the primary visual centre which entails loss of the recognition of things, words, and objects: that is, loss of their significance, object amnesia or apraxia, or true neural blindness.
Total or Compound Aphasia.		Lesion of the entire zone of language: disturbed function of visional, auditory, kinæsthetic-articulatory centres.

HISTORY.—The real history of aphasia dates from 1861. In that year Broca presented an epoch-making communication to the Paris Anatomical Society, which seemed to prove that the morbid anatomy of aphasia was a lesion of the posterior part of the third convolution.

Broca's communication opened a new era in the understanding of speech. It was not, however, more epochal than that which marks the direction of Wernicke's master mind toward a solution of the problems of aphasia in the early years of the seventh decade of this century.

Speech disturbances had been recognized clinically and studied even so far back as the time of ancient Grecian writers, who used the term anandia to signify loss of speech; but the first records of serious attempts to study the faculty of speech from the standpoint of its pathology were made by Bouillaud in France in 1825, by Jackson in this country in 1829, by Dax in 1836, and by Lordat in 1843. Many years before, the brilliant, misguided Gall had located the faculty of speech in the supra-orbital convolutions. Early in the century Lordat seemed to have an astonishingly accurate conception of aphasic speech disturbances as they are understood to-day. The Germans made several early contributions to the study of aphasia, among them being those of Bergemann in 1847, Hasbach in 1852, and Nasse in 1853. In our own country the observations of Jackson must be mentioned, and also those of Rush, Hun, Bigelow, and others. The most important early American contribution made to the subject of aphasia was that of Seguin in 1867.

In England the labors of Russell, Gairdner, Bastian, Broadbent, Ogle, and Bateman contributed largely to our present knowledge; in fact, the names of these physicians are landmarks in the history of aphasia.

In Germany, the work of Wernicke, Grashey, Lichtheim, and Freud did much to extend the conception of the term aphasia and to give rational explanations of some of its subdivisions. Wernicke particularly, in 1874, furnished a basis for the conception of sensory aphasia. He showed clearly that lesion of the first temporal gyrus produced a symptom-complex, constituting what he called sensory aphasia.

Aside from Broca and Wernicke, the three names that stand out above those of all the others who early increased our knowledge of aphasia are Trousseau in France, Hughlings Jackson in England, and Kussmaul in Germany, the latter having written in 1877 what is to-day the soundest and fullest treatise on the subject of aphasia in any language.

In 1881, Exner maintained that there is a separate area of the brain in which are stored the motor memories of writing, destruction of which area causes agraphia. This centre he placed at the base of the left second frontal convolution. The majority of modern investigators and writers on the subject of aphasia are opposed to the existence of such a centre.

they reach the lingual and fusiform lobules bordering the calcarine fissure, we shall appreciate that the angular gyrus is the most direct, the most adjacent, and the most elective place in which the visual images could be stored. In fact, its relationship to the primary visual centre and to the fibres that convey visual impulses, the radiations of Gratiolet, is analogous to the environmental relationship between the centre for articulatory memories and the Rolandic cortex that externalizes speech. The third centre, the auditory centre, the most important of all speech centres, the one by whose functioning speech is developed, the one that conditions speech more than do both the others combined, the one in which words are primarily revived in the vast majority of peoples, the one that is least tolerant of disorder without manifesting itself by imperfections of speech, is situated between these two centres in the zone of language, and occupies the first temporal convolution, and particularly that portion of the cortex which surrounds the temporo-parietal sulcus. It occupies such a position in relation to the distribution of the auditory nerves and the mechanism of hearing that experimentalists as well as clinicians have been led to look upon it as a general auditory area. The centre for the storage of auditory memories is not placed anywhere in the general auditory area; it is placed in the posterior part of the first temporal immediately adjacent to the gyrus in which are stored visual memories. Thus it will be seen that the auditory and visual memories which are contributory to the development of speech and education in general are not widely separated; they are, on the contrary, immediately adjacent. On the other hand, they are not adjacent to the centre in which are stored the memories of articulation, and to which the products of the activity of the former two are sent before they go to the Rolandic area cortex to be executed. Furthermore, the location of the visual and auditory centres on the one hand, and of the centre for articulatory memories on the other, would seem to me to have a very definite suggestiveness in relation to the frontal lobes, which physiologists, psychologists, and pathologists believe to be the most essential parts of the brain for the production of the higher mental processes—judgment, will, inhibition, and emotions—and whose integrity must be maintained if the individual is to develop or persist in habits of attention, concentration of thought, balance of feeling, sound judgment, and moral conduct.

Motor Aphasia.—(1) Cortical motor aphasia; articulatory kinæsthetic aphasia. (2) Subcortical motor aphasia.

Disturbance of speech is manifested predominantly in its reception and emission, and as the reception of speech is dependent essentially on sensation, and only in a contributory way on motion (movements of eyes, ears, extremities—kinæsthetic sensation), the defect in speech that results from interference in the reception and interpretation of speech is called sensory aphasia. On the other hand, communication of thought by speech, and, in fact, communication of thought in any form, is mediated through movement. For the spoken word it is by the coordination of the respiratory movements, the movements of the vocal cords, the palate, tongue, and lips; in writing, by the movements of the mobile part of the body holding the pen and acting under the conscious or subconscious direction of the visual centre; in the case of pantomime, by movements of the muscles of the face and of the extremities. A lesion that disables or militates against externalization of speech is termed, in a general way, and principally for convenience' sake, motor aphasia.

There are two divisions of motor aphasia, cortical and subcortical. Clinically, if they are studied with great care, they can be differentiated, although it must be said that the features which allow us to distinguish the one from the other are not quite so absolute and convincing as one might be led to infer from reading works on the subject. Lichtheim suggested a test for subcortical motor aphasia to prove that patients preserve the memorial notion of the word; that is, that they have in their minds the name of the object which they are incapable of emitting. This test is not infrequently mentioned in literature as the Lichtheim test, but it was first suggested and utilized by Proust in 1872. To test this deficiency of internal language, Proust and Lichtheim showed that it sufficed to ask the patient who had heard some polysyllabic word, or had seen and recognized the object indicated by that word, to press the interlocutor's hand as many times as the word has syllables; and, if not by pressure of the hand, to indicate by some movement the number of syllables; then to indicate by similar pressings the number of letters in the word and the number of letters in the syllables.

The lesion that causes motor aphasia is in the great majority of cases a vascular one, and as the same blood-vessel, the left middle cerebral, is the principal medium of arterial supply for the remainder of the speech area, it is only in exceptional instances that destruction of Broca's convolution is not accompanied by some anatomical perversion of other parts of the zone of language, although these are usually transitory. There is invariably some perversion of function of the other speech centres, because perfect speech demands the harmonious co-operation of all the speech centres, and one cannot be disordered without entailing derangement of all.

Cortical Motor Aphasia (Articulatory Kinæsthetic Aphasia).—By cortical motor aphasia I mean a disturbance of speech due to loss of the sensory images of articulation associated with loss of the sensory memories of co-ordinate movements entering into vocal expression; the latter is not essential, but it is an accompaniment in nearly every instance. Cortical motor aphasia is characterized particularly by a loss of spontaneous and repeated speech, and by the preservation of the capacity to comprehend spoken speech. The peripheral speech mechanism—the tongue, lips, palate, and vocal cords—is in condition to functionate. The only justification for the use of the word motor in this form of aphasia is that the images of articulation are called into being by movement and are externalized by movement. Therefore, in true cortical motor aphasia there exists the same inability to call into being the sensory memories of articulation, and thus to make them a part of internal speech, as there is to externalize them in the shape of articulate words. Many of the cases of aphasia in the literature which are considered to belong in this category are not of this variety at all, but are examples of pure motor aphasia (of Dejerine), or subcortical aphasia; that is, disturbance of speech dependent upon interruption of the projection tracts which convey the articulatory impulses from the cortical area of the peripheral speech mechanism to the peripheral speech apparatus.

Associated with this loss of spontaneous speech, due to the destruction of the sensory images of articulation stored up in the foot of the third frontal convolution, there is a loss of all forms of speech utterance for which an evocation of articulatory kinæsthetic memories is required. Therefore there are inability to repeat words and inability to read aloud, but the patient comprehends spoken words, oftentimes somewhat imperfectly. There is inability to express thoughts in writing, because in writing the motor word representations are always revived by the impulse which travels from the percipient centre (which is either in the visual area of the brain in spontaneous writing, or the auditory speech area in writing from dictation) through the articulatory kinæsthetic centre to that part of the Rolandic region which guides the mobile part of the body holding the pen. On account of the ontogenetic intimacy existing between the receptive speech centres and the emissive, disturbance of the emissive speech centre almost invariably produces some disturbance which is manifest through the former. This is shown in cortical motor aphasia by difficulty in calling up promptly and with readiness auditory word images to which articulatory kinæsthetic images are subservient, and in some degree by a disturbance of internal reading. In the great majority of people it is probable that reading to one's self is accomplished by evoking the images of articulation, and that as a matter of education, of ex-

pediency, a short cut is established between the area in which visual images are stored and the association tracts constituting the anatomical basis of comprehension.

In cortical motor aphasia there is sometimes very complete amimia. This is to be explained by the fact that studied pantomime is associated normally with the arousal of the images of articulation.

If destruction of Broca's area is total, or nearly so, the capacity for articulate speech will be correspondingly complete; while if the convolution of Broca be only partially destroyed, and particularly if the lesion be a vascular one, such as plugging of the branch of the middle cerebral artery that supplies Broca's convolution, with subsequent exudation, a reparative process may set in. Then the degree of the completeness of the aphasia bears some relation—though just how much cannot be said—to the amount of repossession of articulatory images.

The capacity for articulate expression which a few (compared with the entire number) motor aphasics retain is for a few words whose utterance partakes more of the nature of a reflex act or of an emotional possession than it does of a process of intellection.

Another very striking variety of articulate speech which patients with motor aphasia show is that to which the term lalling or lallation is applied.

Although in cortical motor aphasia the power to make voluntary expression is usually entirely gone, the loss may be partial. When partial, the power of expression is limited, as a rule, to one or more monosyllabic words. Occasionally patients who are afflicted with complete motor aphasia are able to utter some words of the nature of an oath, which seem to escape from them in a rapid, uncontrollable way, or to ejaculate words expressive of the feelings. Such expressions are not the product of cognition, but of the emotions, and partake of the nature of reflex action. Other patients repeat continually some expressive or meaningless word or words. Such recurring utterances are distinctive features of cortical motor aphasia, and not of the subcortical variety.

Cortical motor aphasia is sometimes manifest merely by a loss of substantives; amnesia of the names of the things or objects of which the patient tries to speak.

A patient with cortical motor aphasia is unable to express his thoughts in writing. His incapacity to write is proportionate to the amount of derangement of internal language, and it bears a definite relation to the amount of latent or actual visual amnesia of words which every patient with cortical motor aphasia has. In most cases the capacity to write is limited to writing the name and a few other words, such as the age, the address, and the name of the wife or the parents, that have been done so habitually, automatically, and frequently that they form a part of the patient's habitual acts, and are done almost reflexly. However, every modality of writing is not interfered with; though writing voluntarily and writing from dictation are practically impossible, yet the patient is able to write from copy. Motor aphasia is almost invariably associated, at least in the beginning, with right-side hemiplegia, due to extension of the lesion on which the aphasia is dependent to the psycho-motor zone, and this hemiplegia prevents the patient from writing with the right hand.

Subcortical Motor Aphasia—The term subcortical motor aphasia is used to indicate a partial or complete inability to externalize speech which has been properly formed in the speech centres constituting the zone of language. The lesion is one that causes a break in those speech-carrying neurons extending from the portion of the Rolandic cortex to which is allocated the representation of the different parts of the peripheral speech mechanism to the cells constituting the peripheral neurons of the same mechanism. Some recent writers, such as Ziehen, use the term "fascicular anarthria" to indicate the same condition.

The symptoms of subcortical motor aphasia are practically the same as those attending destruction of Broca's area, with two striking and all-important exceptions. The first of these is that the patient retains the capacity to write, which is lost in cortical motor aphasia proportionately to the completeness of the aphasia; and, secondly, the patient responds to the Proust-Lichtheim test; thus proving that he retains the ability to call up spontaneously the sound of the word, the visual image of the word, and the articulatory memory of the word.

When the lesion that causes subcortical motor aphasia is situated at a level as low as the internal capsule, then a diagnosis can often be made positively, not alone from the employment of the Proust-Lichtheim test, but from study of the difficulty of articulation. Such a patient has all the components of internal language absolutely intact, inclusive of the articulatory kinæsthetic images of words. He hears, sees, writes, mimics, and in other ways gives evidence of intellectual integrity. He is incapable only of causing the coordinate movements which subserve articulate speech. He may not be totally devoid of power of articulation; his incapacity may vary from simple slurring and elision of certain syllables and words, through dysarthria, dysrhythmia, up to complete anarthria and arhythmia, and thus complete speechlessness.

In the conventional use of the term, this condition is aphasia; but it is not true aphasia, for true aphasia occurs only with lesion of the area of language. Yet it simulates true aphasia so closely that a differential diagnosis can be made only after very careful study. The nearer the lesion to the cortex, the more difficult will this differentiation be for such cases. All the projection fibres coming from the executive articulatory area are more likely to be involved, and with it there may be some functional perversion (possibly transitory) of the zone of language.

The differentiation of cortical and subcortical aphasia sometimes becomes of great importance from a medico-legal point of view. For instance, a patient who has the symptom complex of motor aphasia due to a subcortical lesion may be just as competent to make a will and dispose of his possessions as a man who has hemianæsthesia due to a central lesion; but a man who has cortical motor aphasia, and thus a derangement of his internal language, entailing some deviation from normal in every component of speech, be it in hearing, in seeing, or in expressing himself (including writing), may be quite incapacitated from such disposition, according to the interpretation of the law.

Cortical motor and subcortical motor aphasia are both almost invariably associated with right hemiplegia, and are dependent upon the same lesion. In the cortical form hemiplegia is apt to be less complete, and the spasticity of the paralyzed parts great. Moreover, it usually follows immediately after the stroke, although it may occur with epilepsy, tumors, abscesses, foci of inflammation, or other conditions which slowly destroy Broca's area.

Sensory Aphasia.—As motor aphasia is used to designate those disturbances of speech expression in which the chief difficulty is in making speech, sensory aphasia is applied to those cases in which imperfections of language, disability or inability to speak, are due to interference with the reception speech forms; that is, to lesion of the perceptive areas of the brain and the immediate incoming and commissural pathways of such areas. The perceptive centres by whose functioning speech is ontogenetically developed are the auditory and the visual, and sensory aphasia is thus practically auditory and visual aphasia, and as such I shall describe it.

Sensory aphasia may be defined as loss of the understanding of words, due to interference with the formation of associations necessary for complete perception. Anatomically speaking, cortical sensory aphasia might be defined as aphasia due to lesion of the posterior part of the area of language, and cortical motor aphasia as due to lesion of the anterior end of this zone. The subcortical forms of each variety occur when there is lesion of the pathways which carry impressions into and away from the zone of language.

Sensory aphasia possesses certain general features which are in many ways materially different from the general features of motor aphasia, and they are explained

by the location and relationships of the different centres. Motor aphasia is almost invariably associated with hemiplegia, while sensory aphasia is rarely accompanied by hemiplegia unless the lesion is a most extensive and severe one. In the case of motor aphasia this is easily explained by the proximity of the convolution of Broca to the motor centres in the Rolandic region and to the motor projection tract. On the other hand, if the lesion be confined to the posterior part of the zone of language, the cortical motor area and the projection tract constituted by its central axones may be entirely spared. Compared with motor aphasia, sensory aphasia is relatively more often associated with lesions that are not primarily vascular in origin. In other words, it is more likely to occur with encephalitis, with tumors, with injury, and with certain degenerative diseases of the brain; and thus its evolution is often very different from that of motor aphasia. Whereas the former is almost always abrupt, and subsequent to an apoplectic stroke which usually entails more or less prolonged loss of consciousness, sensory aphasia not infrequently unfolds itself slowly, and even when due to a vascular lesion it oftener develops progressively or in repeated accessions than does motor aphasia.

Another very striking feature of sensory aphasia is that in the beginning it is the aphasia of comparative speechfulness, while motor aphasia in the beginning is usually absolute speechlessness. Sensory aphasia is characterized by logorrhœa, motor aphasia by alogia. Then the career of sensory aphasia is most instructive. The unfortunate patient starts in with his senseless loquacity, and week after week, sometimes day by day, one notes the shrinkage of his useless vocabulary, through the stages of lalling, and of echoing, down to absolute mutism as complete as that produced by total destruction of the articulatory kinæsthetic area.

Patients with sensory aphasia are rarely reduced to a condition of mutism by such lesion alone, because destruction of the auditory centre is rarely complete. When the lesion of the auditory centre is slight, the most striking abnormality in voluntary speech is the inability to use words with their proper signification, although the words that are used are articulated with as much clearness and distinctness as in the normal state. The patient may utter words that are entirely the opposite of those which he intended to use.

The defect of speech known as "jargonaphasia" occurs oftentimes with sensory aphasia. This may be considered a degree of paraphasia, although the latter is properly applied to a condition in which words are used in an incorrect sense. Jargonaphasia consists of the production of a jumble of words all forged into one, the syllables of which may be articulated, but the words have no similarity to words as usually spoken.

Not secondary in importance to the information that may be obtained of sensory aphasia from a study of articulate speech, is that which is to be had from an examination of the spontaneous, dictated, and copied writing. Patients with pronounced sensory aphasia are not usually hemiplegic, so that tests for defects of writing can be undertaken without trouble if the patient be made to comprehend what is wanted. Defects in writing are most striking when visual aphasia is the prominent feature of the aphasia, although they occur in every case of sensory aphasia. The degree to which spontaneous writing may be preserved or lost in sensory aphasia varies with the patient, and with the seat and the intensity of the lesion. Oftentimes there is preserved, even in cases of genuine visual aphasia, the ability to write a few words spontaneously. If the patient has destruction of the angular gyrus, there will be practically total agraphia. If the lesion is principally a destruction of the auditory area, there will be absolute inability to write from dictation; and even though writing spontaneously may be preserved to a very limited extent, the words or sentences produced will be markedly disordered in their arrangement.

The power to write after copy is preserved in every case of genuine sensory aphasia, but the patient copies in a way that at once puts the stamp of his infirmity upon his work. He copies letters the way a beginner does a drawing, and makes an exact reproduction of what is before him.

In *auditory aphasia* there is inability to understand spoken words. This is dependent apparently upon the total loss of auditory verbal memory images. It is one of the uncommonest forms of aphasia, and it rarely occurs independently, being frequently associated with some degree of visual aphasia or motor aphasia.

The seat of the lesion which causes auditory aphasia is the cortex of the middle and posterior portions of the first temporal convolution, extending over into the second temporal and upward into the supramarginal convolution, where it impinges upon the cortical area for visual verbal images.

The symptoms of auditory aphasia are subjective and objective. If the aphasia is limited to simple word deafness, the patient hears the voice in which words are spoken, but the words convey no idea to him, and he has no more comprehension what they mean than if they were spoken in a tongue which he never before had heard. He, however, recognizes the significance of other sounds, unless it be that the memory pictures for such sounds are also lost. Naturally there are different degrees of word deafness, depending upon the extent of the lesion or the destruction of the auditory area. In some cases the extent is so great that the sound of the voice which speaks them is simply perceived as a sound, and such patients do not recognize the sound of their own name. In other instances they recognize the sounds of their own names, and possibly the names of other members of their family, their places of residence, business, etc.

In the milder forms of auditory aphasia it is often necessary, in order to estimate correctly the degree of word deafness, to test the patient carefully and repeatedly.

The concomitant accompaniments of word deafness are inability to write from dictation, defective comprehension of what is read, imperfect writing, paragraphia, etc. The first needs no explanation. The power of internal reading is disordered, because the primarily excited visual word centre, in transmitting the impulses to the auditory area, finds the latter disordered, and there is in consequence defective revival of corresponding word memories and lack of comprehension of what is read. The paragraphia is an expression of the disorder of internal language, which is always present in true auditory aphasia.

A patient with word deafness, having a lesion that cuts him off from the significance of all that is said to him, is practically rendered deaf. He is quiet and observant; his glance betrays suspicion or fear, and his demeanor is often one of trouble and unrest. This change of demeanor and manner, the inability to repeat from dictation, and the profound diminution, even to complete absence, of spontaneous speech, have often led physicians and laymen alike to look upon these unfortunate patients as insane.

Word deafness rarely, if ever, exists alone. It is often associated with cortical motor aphasia, and frequently, on account of the proximity of the auditory area to the visual area, with some degree of word blindness.

There must necessarily be as many forms of auditory aphasia as there are distinctive symbolic sounds. Spoken speech is the most highly symbolic, the next most differentiated to music. To the form of aphasia in which there is deafness for musical notes the designation tone deafness (musical deafness) is given. Musical deafness is almost always associated with word deafness, but there have been a few cases recorded in which it occurred apart from the latter.

The clinical forms of amusia are strikingly analogous to the clinical forms of aphasia, and they generally accompany the latter, although the different varieties of amusia have some clinical independence.

Visual Aphasia; Verbal Blindness; Word Blindness.—This is a form of aphasia in which there is a loss of the significance of written or printed words, although the

words themselves can be seen with customary distinctness. In the form of aphasia described as verbal blindness the patient can see the word perfectly, but he gathers no meaning from it. The peripheral visual apparatus is intact. A printed page of a language previously entirely familiar to the patient suffering from this form of aphasia conveys no more meaning to him than does a page of Greek or Hebrew to the illiterate, or a page of Chinese symbols to him who reads only English, although he sees with the greatest distinctness the letters printed or written, and he may even be able to tell the handwriting of one person from that of another. As in word deafness, in the literal interpretation of the term, the defect is not word blindness, but loss of the significance of graphic words. Words seen do not arouse a corresponding content of consciousness.

Word blindness may be classified according to the degree of its completeness and according to the kind of concrete written or printed symbols which we associate with ideas, such as algebraic symbols, musical notes, geometrical figures, hieroglyphs, etc., that the patient is unable to recognize. When the unmodified term word blindness is used, it is understood that other forms of printed and written symbols than letters and words are seen and interpreted, and that they call forth corresponding ideas.

The visual area is in the posterior end of the brain. It is made up of two more or less distinct centres: a visual perceptive centre and a centre in which is stored the visual memory of words and other symbols. The former is situated on the mesial surface of the occipital lobes in the environmental area of the calcarine fissure; the latter (usually known as the visual centre) is in the posterior portion of the inferior parietal lobule, the angular gyrus, and the adjacent margin of the supramarginal convolution which curves over the posterior extremity of the fissure of Sylvius. Destruction of this centre produces a form of sensory aphasia in which there is inability to put interpretation on words seen and consequent inability to read—the condition known as word blindness, alexia, but it causes no loss of visual acuteness. The primary visual area and the higher visual centre are frequently diseased simultaneously, but the symptoms produced by each can be differentiated. In these cases it is to be understood that there is no lesion of the peripheral visual apparatus, although the condition known as homonymous hemianopsia oftentimes exists.

Word blindness in its simplest form entails alexia, inability to read, or inability to get any information from written or printed symbols. Naturally there are various degrees of intensity of word blindness. The patient may be unable to read words, and yet retain the faculty of recognizing letters; or, on the other hand, this may also be lost, constituting literal as well as verbal blindness; or he may be able to recognize letters and unable to join them into syllables (asyllabia).

In many cases of visual aphasia, or word blindness, the patient, although absolutely unable to recognize anything else, still tells his own name when he sees it written. But unless he has been accustomed to see it in print, he will not recognize it. In such cases it is understood that the angular gyrus is not completely destroyed. Oftentimes the patient will preserve a recognition of a number of other words, particularly of names with which he has been for a long time familiar. Occasionally cases are met with in which the verbal blindness is so very slight that it requires careful and persistent examination to reveal it.

If the angular gyrus is completely destroyed, the faculty of writing is lost with it. In those cases in which voluntary writing is preserved, the lesion involves the primary visual centre, and, as this lesion is so often associated with right homonymous hemianopsia, the patient begins to write at the extreme left side of the sheet and stops in the middle of the page. These patients, being unable to read what they have written, are totally unconscious of any errors of spelling or phraseology that they may make, although they may put the words on paper in as orderly a fashion as they were able to do before the development of the aphasia.

If the auditory centre is uninjured, the patient is able to comprehend what is read to him, and if his own handwriting is read he may be able to detect errors of sequence, of diction, and of spelling, but he is unable to take a pen and correct them.

Patients with word blindness are sometimes able to read written or printed words and sentences by tracing the word with the end of the index finger or with a pencil. Such patients, by utilizing kinæsthetic stimuli, excite previous kinæsthetic memories, which in turn react upon or act conjointly with auditory and articulatory memories to revive the mental concept of the word.

The patient may not be blind to all forms of notation, graphic and symbolic representation. Thus there may be sensory amusia, sensory asymbolia, sensory amimia, etc.

There are two or three subdivisions of visual aphasia, to which I shall refer. The first is the form in which there is loss of the perception of the word, not only of the visual impressions corresponding to the word, but a loss of the value of the symbol in arousing the idea of which it is the written representation. This form of sensory visual aphasia is entitled to the name "loss of word visualization," verbal amnesia, or psychic blindness of words. Unlike word blindness, the patient interprets letters as letters and words as words, and he can read them and copy them, but they convey no meaning to him after he has read them. When they are pronounced before him he hears and interprets them very readily, but he has no idea that they are the same words that he has been reading or copying unless he is so informed.

The lesion which produces such a condition is one that interferes with the pathway that conveys the sensation from the printed word or object to the idea, or to where the idea is formed.

A second subdivision is that in which the patient, on looking at an object which he has previously seen and used, is unable to call up its name, although he is in condition to utter the name if he could call it up. This is the condition to which the name "optic aphasia" has been given by Freund. The striking symptom is the inability to name things. The lesion interrupts the pathways that unite the seat of cortical visual representation and the seat of cortical auditory memories.

In addition to the kind of visual aphasia in which there is loss of memory for written and printed letters, and to which the name "verbal amnesia" or "psychic blindness of words" has been given, there is a form of less common but more striking occurrence, known as psychic blindness or mind blindness, the "Seelenblindheit" of the Germans, "Cécité psychique" of the French, a condition not infrequently associated with the ordinary form of word blindness and letter blindness. In this condition the patient not only does not recognize the significance of letters, but he loses the power to differentiate between familiar objects or persons and to distinguish the use of things.

The condition known as apraxia—the inability to comprehend the usage of ordinary objects and things to which one has been accustomed—is analogous to this. The nature of the apraxia is probably an abolition of the visual memories of objects, which memories have been stored up in the higher visual area, a condition analogous to that of word blindness. The patient who has this condition may see the object; that is, he sees it objectively, but he does not see it subjectively.

The subcortical forms of sensory aphasia, pure sensory aphasia of Dejerine, are analogous to the subcortical forms of motor aphasia. The lesion of subcortical sensory aphasia is one that interferes with the passage of the spoken and written word to the idea of the word or to where the idea is formed, it being understood that the structures by whose functioning the idea of the word is formed are intact.

The real components of sensory aphasia are visual aphasia and auditory aphasia, and it follows that the visual cortical area and the auditory cortical area are the

parts by virtue of whose activity one gets a visual and auditory idea of words. Therefore, there may be a subcortical interruption of the visual and auditory pathways which causes a subcortical visual aphasia and a subcortical auditory aphasia.

In subcortical visual aphasia connection with the primary visual centres is severed, and consequently the higher visual centre, although retentive of its anatomical integrity, is perverted in its physiological ability. The connection of the visual centre with the other speech centres is not disturbed, except in so far as the latter are not properly and customarily influenced on account of the fact that the visual centre itself does not receive customary stimuli. This accounts for the occasional occurrence of shortcomings of speech (slight paraphasia, such as noted by Bramwell), which might otherwise seem paradoxical.

The symptoms of subcortical visual aphasia vary somewhat with the seat of the lesion, *i.e.*, with its proximity to the left angular gyrus. Generally speaking, they are verbal blindness, always associated with right lateral homonymous hemianopsia, as the lesion is either of the primary visual area, in the cortex of the occipital lobe bordering on the calcarine fissure, or of the optic radiations connecting the occipital lobes with the left angular gyrus, the higher visual centre.

Spontaneous speech, except occasionally the slight paraphrasia already referred to, and capacity to repeat are intact. The patient is able to write voluntarily and from dictation, but he cannot read what has been written any more than he can read what some one else has written, except in those instances in which the sense can be gathered from tracing each letter with the finger tip. The patient understands readily what is said to him and can reply intelligently and correctly.

Subcortical visual aphasia may or may not be accompanied by a degree of optic aphasia manifested by inability to name objects. Whether or not these patients have any difficulty in spelling needs further investigation. In all probability they do not, save in rare instances.

Subcortical word deafness, or pure word deafness of Dejerine, is characterized especially by inability to understand spoken words, and, naturally, by inability to write from dictation. It is of much less frequent occurrence than subcortical visual aphasia. The feature that distinguishes it from cortical auditory aphasia is the fact that spontaneous speech is preserved, there is no amnesia verbalis, the patient is able to read aloud, to write voluntarily, to copy, and to read understandingly what he and others have written. As in every other form of subcortical aphasia, every constituent of internal language is intact. It is rarely if ever associated with paralysis of the extremities.

Occasionally cases of aphasia are encountered in which there is a disturbance of all forms of intellectual expression, involving disturbance in the reception of stimuli which condition mental states preparatory to speech, and disturbance in the emission of such mental states. To such cases the name total aphasia is given because it includes the phenomena of both motor and sensory aphasia.

Diagnosis.—The first step in attempting the diagnosis of aphasia is a simple method of eliciting and associating the different symptomatic constituents. It should be kept in mind that the speech faculty consists of two parts, the receptive and the emissive, and that either of these two parts may manifest the predominance of the aphasic symptoms, but that in true aphasia, that is, aphasia dependent upon lesion of the speech centres, neither can be the sole medium of manifestation of the speech defects. It should further be remembered that emissive speech is manifest by articulation, by writing, by pantomime, and that integrity of the receptive side of language is commensurate with the interpretation of visual and auditory stimuli.

The attitude, the demeanor, the conduct of the patient may be of the greatest service in orienting the physician, from the very beginning of the examination. The demeanor and expression of one with auditory aphasia are frequently those of a person who has lost all interest in his surroundings, and his attitude is that of a deaf person who is slightly demented. The same is true, though to a lesser degree, of the patient with visual aphasia. Moreover, patients who have this form of aphasia are often garrulous, and on the slightest provocation, or without provocation, emit a string of articulate or gibberish sounds that convey no meaning to those about them. This is especially true of cases of not very protracted duration. Patients with cortical motor aphasia and with subcortical motor aphasia, on the other hand, present a very different aspect. They are often absolutely silent but watchful, and the intensity with which they hold every move of the persons surrounding them is often striking. This intensity of observation is particularly to be marked in cases of subcortical motor aphasia in which the patient is absolutely speechless yet capable of the fullest understanding of all that goes on about him and within his hearing and vision.

A number of schemes have been devised to facilitate the examination of aphasic patients, but I have found the following simple plan most serviceable. After securing a general history of the patient's life and of his previous illness from some member of the family, and in this way getting information of the character of the disease of which the aphasia is a symptom, the patient's ability to express ideas, to receive and interpret information, should be inquired into. The mental processes, apart from the manifestation of mental states and the mental capacity for the reception of sensory stimuli, should then be examined. Although a number of these may be determined simultaneously, it is best to take each one separately.

In approaching a patient with aphasia it is natural that the endeavor should be made to elicit information by speaking to him. It becomes necessary, therefore, to determine if the patient takes note of what is said to him orally, and, secondly, if he understands what is said. In other words, does spoken speech awaken in his auditory centre corresponding memories? This can be done ordinarily by asking some simple question, as, "How long have you been sick?" or by addressing to him some simple command, such as, "Give me your hand." Care must be taken not to employ too conventional questions or commands, such as, "What is your name?" "Put out the tongue," etc. The patient may have lost the auditory apperceptive faculty and still, oftentimes, make reasonable reply to such questions, merely from association and habit. Naturally the patient should get no information of what is being asked through any other avenues than those of hearing. Such patients are quick to grasp, particularly if they have been aphasic for some time, the significance of even slight emotional expression or pantomime on the part of the interlocutor. If the patient does not reply to such questions or commands, there may be trouble with the receptive or with the emissive speech faculties. If he is word-deaf—that is, if the trouble is one that prevents the sound of the word from reaching the centre in which the memories of previous word sounds are stored up—the patient will not endeavor to respond by word or act, though in some instances he does so. Nor will the face show the slightest response or indication of comprehension. If he does respond, the diagnostic feature is that his answer, even though it be made up of articulate words, has no pertinency or bearing on the question. If the patient is not word-deaf, he will make some movement, be it of the head, hand, or features, to indicate that though he understands he cannot reply. Generally this gesture is very significant. It consists of a despairing expression of the countenance and a touching of the lips or the throat with the fingers. Oftentimes the question can be decided very quickly, if there remains some doubt even yet, by asking some absurd or ludicrous question and noticing how the patient receives it. If, in reply to the question, "Are you one hundred years old?" he solemnly says, "Yes," or if he does not see the ludicrousness of a request to turn a somersault when he is obviously para-

lyzed, it is rather convincing proof that such speeches do not awaken the proper responses in his mind; and if there be no dementia, it is suggestive evidence that the patient is word deaf, and the examination should then proceed from that standpoint. Although other of the speech centres may be simultaneously disorganized, the symptoms attributable to the first one will dominate the character of the speech defect. If the examination so far seems to suggest the existence of word deafness as the leading feature of the sensory aphasia, it should then be determined to what degree of completeness this exists, and the extent and kind of disturbance that it causes in the externalization of language. The amount of diminution of the patient's vocabulary, the degree of inappropriate usage of words, the imperfections of sequence and rhythm, should all be noted. The patient should be tested for his power of recognition of simple words, short sentences, and long sentences. As he may react to conventional questions, such as, "Put out the tongue," etc., uncommon requests, such as, "Touch the nose with the tip of the index finger," or "Stand on the chair," should be made. The ability of the patient to interpret sounds should then be noted. Do sounds evoke previous memories of similar sounds, and do they incite the auditory centre to revive the name of the object from which such sounds proceed? When a bell is sounded, or a watch is held behind the ear and apart from the stimulation of any perceptual avenue other than hearing, can the patient say, "Bell" or "Watch"? Finally, the existence of any disturbance of bone or aërial conductivity should be demonstrated or excluded.

If word deafness can be excluded, and the patient still makes no reply,—that is, if he remains completely speechless,—the examination should be made to determine whether or not internal language is defective, for it must be readily seen that the question has then narrowed itself to a determination of whether or not the aphasia is cortical motor (kinæsthetic word image) aphasia, or, whether it is subcortical motor aphasia. In other words, is the inability to speak due to a lesion of the storehouse of kinæsthetic memories of articulated words, Broca's area, or is it due to a lesion of the neurons that conduct the motor word impulses from the Rolandic area to the parts that externalize the word? The essential thing then is to determine if the patient is in full possession of internal language. If internal language in any of its components is disordered, then the patient has true cortical motor aphasia. If, on the other hand, there is no such disturbance, the lesion is elsewhere than in the zone of language. In some patients the differentiation will be an easy one. On the other hand, however, the task is oftentimes an extremely difficult one. It is particularly so because the test to determine if the legitimate idea of words can be evoked in the internal language (the test of Proust and of Lichtheim) is not one of universal application, because in the first place many patients have not sufficient scholarship to know anything of syllables or word construction. In the second place, there is very often associated with aphasia, and a concomitant of the disease giving rise to the latter, a degree of deficiency in the associative faculties that amounts to a slight degree of dementia. In such patients it is often extremely difficult to make them understand just what is meant by telling them to press the physician's hand as many times as there are syllables in the word Constantinople, or some equally resonant and polysyllabic word. Nor is the substitute suggested by Dejerine, of asking the patient to make voluntary expiratory efforts as many times as there are syllables or letters in a word more applicable. But even when we cannot get the patient to respond to these tests, there is a general atmosphere about the patient with subcortical motor aphasia that one cannot be long in without recognizing that the patient is in full possession of his intellect and internal speech. The only shortcoming of the subcortical motor aphasia is inability to articulate. He understands everything that is said to him; he interprets information received through the visual sphere; he is capable of expressing his thoughts fully, easily, and correctly by writing and by pantomime, or, at least, he would be if it were not that the right half of the body is usually paralyzed, and he is obliged to portray mental states by the pantomime activity of the left, the less dextrous half of the body.

Physicians oftentimes find some difficulty in properly assigning cases of cortical motor (articulatory kinæsthetic) aphasia, because the patient is still able to articulate some words. If it be kept in mind that the patient with cortical motor aphasia (articulatory kinæsthetic) need not be absolutely deprived of the power to articulate words; that he frequently retains the ability to say one or several words, which he uses at all times and under all conditions, and that frequently these words take the form of recurring utterances; that there is always agraphia, which may be very evident or which may be difficult to bring out because the patient pleads paralysis of the right hand as an excuse for not making an effort to write; that the agraphia is usually proportionate to the aphasia; that it is manifest in voluntary writing and in writing from dictation, but not in writing from copy, and that the patient in copying copies print in script and script in script, showing that the copying is not a mechanical but an intellectual act; and that there is defective internal speech, as shown by the test of Proust and Lichtheim, then the diagnosis of articulatory kinæsthetic aphasia will not be a difficult matter.

After voluntary speech has been satisfactorily examined, tests should be made to determine the patient's capacity to repeat. There is inability to repeat in both motor and sensory aphasia, and if word deafness has been excluded there will be no difficulty in determining this inability, which is coexistent with loss of voluntary speech in articulatory kinæsthetic aphasia

Particular attention should be given, in every case of aphasia in which the symptoms point to destruction of Broca's area, to the faculty of writing.

After having tested the patient's capacity to perceive and interpret words through the auditory apparatus, he should be examined with a view of determining if there is any disability of acquiring and interpreting information through the visual apparatus. To do this requires patience and circumspection. In the first place it should be established that the patient has no trouble with the peripheral apparatus. This can be done by an ophthalmoscopic examination. Tests should be made to determine the existence of hemianopsia. This is not an easy matter to do if the patient is aphemic or if he has word deafness; in fact, it is extremely difficult to do satisfactorily. With a patient who can understand what is said to him and who can indicate when he perceives the entrance of an object into the visual field, who can tell when the indicator of a perimeter passes beyond the range of vision, testing for hemianopsia is a very simple matter. If the patient is word-deaf, and if he has visual blindness, which, of course, he is apt to have if he has hemianopsia, one finds himself unable to convey to the patient by written or spoken word that which one wishes him to do or to observe. In such cases one must content himself with the information that is to be derived from forcibly and suddenly thrusting some object into the visual fields, from the right side (for right-handed patients invariably have right lateral homonymous hemianopsia when they have any), and taking note whether or not the patient blinks, as he should do if the object be perceived. If he does not, it is rather certain that he has hemianopsia. Each eye should be examined separately and the findings noted on a chart.

In testing the patient to determine the integrity of the visual mechanism one may begin by showing him familiar objects. If he does not recognize them or show by act or deed that he comprehends their uses or purposes, if he looks upon them as does one who sees them for the first time, then he has object aphasia and the lesion is of the occipital cortex. Such an individual may obtain information through the medium of other special senses, such as the tactile, gustatory, etc. that will enable him

to recognize the object, the person, or the thing. If he is shown familiar objects and he recognizes them, knows what they are for, but cannot name them, then he may have either an interruption in the pathway leading to the higher visual centre in the angular gyrus, or there may be lesion of the angular gyrus itself. If it be the former, internal language will be preserved and spontaneous speech may be intact, although there is usually some paraphrasia and possibly jargonaphasia, and this preservation is shown most conclusively by the retention of ability to write. He may write easily and moderately well, not only voluntarily but from dictation; but the patient is unable to read what he writes. If the aphasia be of the latter character and complete, the patient will be absolutely agraphic. This agraphia is to be considered a part of the disorder of internal language; there is inability to arouse the visual image of the word. In such a case, an arousal must precede the transmission to the part of the Rolandic cortex that innervates the member holding the pen; there is complete agraphia.

The physician then proceeds to examine whether the patient has word blindness; that is, whether the patient can read (1) print, (2) script, (3) figures and other forms of notation.

In cases of complete aphasia the examination is very difficult, and to one not accustomed to such a task it seems very unsatisfactory, as he is apparently unable to communicate with the patient or to receive any information from him.

Etiology.—Etiologically, aphasia may be classified into organic and dynamic. The principal organic forms are due to rupture of the blood-vessels and occlusion of their calibres, whether from embolus or from thrombus, and the consecutive changes dependent thereon. The lesions of the blood-vessels may, however, be due to inflammatory conditions of the vessels, but even then it is not at all improbable that the pathogenesis of the lesion is the direct result of a septic or infectious process that causes infectious emboli and thrombi. The traumatic conditions that may produce aphasia are bullet and stab wounds, depressed fractures of the skull, and injuries producing meningeal hemorrhage.

Under the dynamic forms may be included those in which no organic lesion is responsible for the development of aphasia symptoms. The term dynamic is used merely as a convenience in preference to the conventional "functional." The dynamic variety includes aphasia occurring with neuroses and psychoses which are not yet proven to be dependent upon some recognizable brain lesion, of which epilepsy, neurasthenia, and hysteria may be taken as examples. It also embraces most of the cases of aphasia occurring with toxæmia, such as uræmia, diabetes, and gout; although aphasia in some of these cases, especially aphasia occurring with uræmia, is often dependent upon organic vascular lesion of the cerebral blood-vessels. Aphasia caused by the vegetable poisons, santonin, belladonna, tobacco, etc., is almost invariably of the dynamic form. The aphasia that sometimes occurs in individuals who have been poisoned by lead, copper, etc., may be of the dynamic variety, or it may be a focal manifestation of the encephalopathy which these poisons occasionally cause. The dynamic aphasias also include the aphasic speech disturbances occurring with neuralgic affections of a migrainous order, those occurring with forms of insanity that have no known anatomical basis, and finally, the comparatively insignificant number which are attributed to fright, anger, so-called reflex causes, such as intestinal worms, and the transitory aphasias from loss of blood.

Ordinary etiological factors, such as age, sex, occupation, etc., have no bearing on the causation of aphasia, because it is itself a symptom, and it results only when the diseases of which it is a symptom occur or are prone to occur; but as aphasia is so often associated with cerebral apoplexy, and as cerebral apoplexy occurs usually in late maturity and advanced age, it follows that aphasia is seen oftener in people beyond fifty years of age. Nevertheless, it would be misleading to leave this statement unmodified, for the reason that three diseases which not infrequently have aphasia as a symptom, namely, uræmia, acute hemorrhagic encephalitis, and tuberculous meningitis, are particularly liable to occur in the young. Moreover, aphasia sometimes develops in the wake of the infectious diseases, typhoid, diphtheria, and pertussis, and, as these occur more frequently in youth than at any other time, it follows that the aphasias of this variety will be seen oftenest at such time of life.

Treatment.—The medicinal treatment depends entirely upon the nature of the lesion that causes the aphasic symptom complex. If the lesion be a focus of encephalomalacia, then all that can be expected is to assist nature to prevent further destruction of tissue, and particularly to assist in preventing a repetition of the immediate exciting cause of the softening. On the other hand, if the lesion be a gummatous meningitis, or an isolated gummatous formation in the zone of language or in the subcortical speech tracts, and these can be diagnosticated as such, medicinal treatment is of the greatest value. The difficulty in cases of this kind is oftenest with the etiological diagnosis. Usually the patient is not in condition to vouchsafe any information concerning himself, and as his family are, as a rule, ignorant of such matters, the physician is compelled often, if he has not been familiar with the patient's history, to make a diagnosis of previous syphilitic infection on less satisfactory data than are ordinarily considered essential.

It would be a work of supererogation to repeat in detail the causal treatment applicable to the different forms of aphasia. The treatment for aphasia in one patient may be just as different from the treatment applicable to the next one, as the causes are different. For instance, the treatment in the beginning of an uræmic attack is venesection if the patient has not an organic form of renal disease; yet this kind of treatment would be fatal to a patient whose aphasia was dependent upon autochthonous thrombosis.

When aphasic symptoms develop slowly without fever and with symptoms of increasing intracranial irritation and pressure, then tumor and abscess must be thought of. In making the diagnosis and the differentiating diagnosis one must be guided by the general rules applicable to the solution of these problems. When there are grounds for the belief that the lesion is of a luetic nature, then the administration of mercury and iodide of potassium cannot be carried out with too great promptness and attention.

The treatment of aphasia dependent upon organic disease, such as tumor, abscess, purulent meningitis, and focal disease of any nature, does not differ from the treatment of these conditions when aphasia is not present. When their presence is attended by symptoms which seem to indicate that they are amenable to surgical treatment, their removal should not be delayed. In fact, the aphasia is oftentimes the localizing symptom that makes diagnosis positive and operation possible.

Taking it all in all, the question of the medicinal treatment of aphasia never comes up for consideration The question that does present itself is, How shall we treat the condition of which aphasia is the symptom? To answer that question satisfactorily requires an intimate knowledge of the therapeusis of all the diseases, functional and organic, that have been enumerated in the section on etiology, with which aphasia may be associated. Treatment may consist of such a simple matter as the interdiction of alcohol in a case of toxic dyslexia, or it may require the combined skill of the physician and surgeon to diagnosticate and remove an abscess or tumor. The treatment of the dynamic aphasias is a different matter from the treatment of the organic aphasias. In the former all that is necessary is to remove the cause and the symptom will disappear, while in the latter the cause may be removed and the pathological condition which it has excited still continues and with it the aphasia. Despite this many of the dynamic or "functional" aphasias yield to appropriate medication for the conditions upon

which they are dependent, combined with fitting treatment addressed to the mental, moral, and physical sides of the individual.

The pedagogical treatment of aphasia is a matter of recent development. It has been the legitimate result of an inquiry into the physiological and psychological antecedents of articulate speech and of clinical observations that when a young person becomes aphasic, even though the lesion be a very severe and extensive one, the faculty of speech may still be restored to him. Moreover, almost from the very beginning of the history of aphasia it has been recognized that even when the so-called "speech centre," meaning Broca's area, has been completely destroyed, the patient may occasionally regain some capacity to speak single words or a number of words. Various hypotheses have been formulated to explain these occurrences, the most widely accepted apparently being that of J. Hughlings Jackson, who suggested twenty years ago that the "uneducated centre" of the opposite side is in a way related to conventional, emotional, and other forms of what he terms "degraded" speech, in contradistinction to intellectual speech. This is the theory accepted by many writers to-day. Recently Wyllie has framed a theory along somewhat the same lines, on the "Overflow of education into the opposite hemisphere;" the hemisphere that contains the zone of language takes up all that it can in the way of education, and that which it is not equal to taking up flows over into the other hemisphere. The entire subject of the repossession of the speech faculty in patients in whom it has been lost must needs be looked at to-day from another standpoint than it was a few years ago, when the forms of subcortical aphasia had not been satisfactorily differentiated. It seems to me that in the light of our present knowledge of aphasia it must be granted that not only do the corresponding areas of the opposite hemisphere sometimes, under the stress of education, undertake, in a very incomplete way, the speech function of the destroyed area of the hemisphere phylogenetically and ontogenetically prepared to carry on the speech faculty, but that the immediate environmental areas of the speech centres of the left hemisphere may take up the function in part. In the process of functional compensation the portion of the speech centre that is not destroyed becomes connected with the other speech centres in previously unaccustomed ways, not by the development of new commissural fibres, but through their acquisition of functional activity. Secondly, the opposite hemisphere, the one that has the zone of language ontogenetically developed, is not an uneducated hemisphere at all, but it is, in one sense, just as much educated as the hemisphere in which the zone of language is situated.

It must needs be admitted that there is a general auditory area, a general visual area, and a general kinæsthetic area in the right hemisphere as well as in the left hemisphere, and that in-coming stimuli make on it an impression similar to that which they do on the so-called "educated" hemisphere. These impressions are bilateral in reception but unilateral in interpretation. This unity of interpretation is determined by commissural fibres of the corpus callosum. Now the same factors that determine right-handedness determine also that the left hemisphere shall be the executive speech side, but the elementary work is done on both sides. It seems to me that so far every one who is willing to accept the suggestions of experimental physiology must go. How many are willing to admit that the execution of speech is an automatic act and requires no conscious preparation, if process of anatomical completion is not considered "preparation," is another matter. Those who believe that the execution of speech is an automatic act, find it easier to explain how an approach to automatism, or an unfinished automatism, can be assumed by the opposite hemisphere, which is educated but which is not intended to be automatic, and especially in young children in whom the habit of automatic activity has not become fixed by continued practice. A number of the cases that have been reported to show the assumption of speech function by the opposite hemisphere have been conclusively shown to be dependent upon a subcortical lesion and not upon destruction of a speech centre, and the partial or complete recovery of speech was commensurate with a disappearance of the conditions that had determined the partial interruption of the conducting fibres. In these cases recovery of speech has gone on *pari passu* with disappearance of other symptoms, such as hemiplegia, for instance. In other cases in which the lesion has been of the speech centres, the partial repossession of speech has been due to the fact that the entire speech centre, which in the beginning of an aphasic attack was completely overthrown, has in a slight measure righted itself after the exudative and occlusive conditions have subsided. Then the patient finds himself in possession, to a very insignificant degree, of his previous speech endowment. In other cases there can be no question that the educated areas of the other hemisphere develop some executive capacity. This is determined artificially, *i.e.*, by education, and not ontogenetically as it is normally, except to the very slightest degree.

In brief, then, the education of an aphasic patient should consist in endeavoring to cause the centre or centres in the left side of the brain that are not destroyed by the lesion which causes the aphasia to take the initiative in the primary recall of words and complete the "circuit" necessary for internal language and speech by forcing the educated opposite side to supply a centre similar to that which has been destroyed; or, if the damaged centre is not entirely destroyed, by re-educating the cells that remain, assisting them as it were in the acquisition of a function which they were intended to perform in unison with other cells. For example, if the articulatory kinæsthetic centre is destroyed, the primary revival of the word that should be spoken is through the auditory centre, and this calls up in temporal coincidence or succession the visual and the articulatory. The articulatory centre being destroyed, the speech impulse of the formed word cannot be completed, and the kinæsthetic articulatory centre of the opposite side is acted upon through commissural fibres in just the same way as the articulatory centre of the left side was, through intercentral fibres, in the beginning. The process of education is very slow and must be given artificial aid in the way of showing the patient how to arrange the organs of articulation for the production of simple vowel and consonant sounds, a performance which he should be daily encouraged to do. After he has acquired the capacity to produce these sounds and has regained some control of the peripheral speech mechanism, he is to be tutored in the same way in the production and articulation of monosyllables and their combination in words. This process is a laborious one and requires great perseverance on the part of the physician. Whenever possible the task should be entrusted to a teacher. Naturally the greatest progress will be made with cases of subcortical motor aphasia, because these patients take a more intelligent interest in the matter and because they can aid themselves by reading and writing. Most of the published cases of marked functional compensation have been cases of subcortical motor aphasia, in which ability to read has been preserved.

When the auditory centre is diseased, then the object of teaching is either to get a primary revival of the idea of words in the visual or the articulatory centre, and then to throw into the circuit the component parts of the auditory that are not disorganized, or to favor the development of the auditory word centre in the opposite hemisphere. The patient must be taught to concentrate his attention on vowel sounds and then on words of one syllable, spelt letter by letter, while he tries to repeat them by the oral method. This is a very much more difficult matter, because in the vast majority of peoples the primary revival takes place in the auditory centre, and when this is destroyed the patient is left stranded, from a speech standpoint. The plan of education is in reality that which is used for deaf-mutes who are taught

to think by the revival of the word impulse by the visual centres, the revivification of visual symbols being prompted by hand or lip movements.

Patients with the auditory form of sensory aphasia should be patiently taught to repeat words, the meaning of which is conveyed to them through other senses, the visual, tactual, and olfactory. It is apparent that most progress will be made with patients whose general intelligence is least disturbed. In subcortical word deafness the amelioration is always greater than in sensory aphasia due to destruction of the supertemporal gyrus.

The treatment of sensory aphasia conditioned by destruction of the visual centre is most unsatisfactory, and very little can be done to ameliorate the condition of such patients even though all modes of education be assiduously employed. An effort should be made to teach the patient the recognition of forgotten symbols in connection with the arousal of other memories of them, the auditory and the articulatory. In short, the pedagogical treatment of aphasia embraces the methods of the kindergarten and the methods of instruction for those defective in one or more of the special senses. Even with their aid but little can be done, except in the subcortical varieties. *Joseph Collins.*

APHRODISIACS.—Aphrodisiacs are agents whose employment is supposed to increase sexual desire or ability. A division might be made by classing together those causing increased desire or ability temporarily, as do small amounts of alcohol or other stimulant, and those doing so permanently; or a division might be made of those increasing desire as opposed to those increasing ability to perform the sexual act. In no condition must the maxim "remove the cause first" be more considered, and we are dependent upon general measures after the cause has been removed rather than upon the employment of drugs.

Loss of sexual power may have origin in various ways and is frequently divided into *organic*, *psychical*, *nervous or irritable*, and *paralytic*. *Organic* impotence is dependent upon structural change, either congenital or acquired, such as anomalies, malformations, new growths, etc., for which relief must be sought by surgical or other special treatment.

For *nervous* or *irritable* impotence, which is due generally to weakness of the genital organs and abnormal excitement of the reflex centres causing premature ejaculations, or due to irritations caused by some morbid condition of the urine or by the presence of strictures, resource must be had to measures such as the passage of a cold sound and other local treatment, which will relieve the causative factor. In *paralytic* impotence, which is usually caused by structural changes in the nervous mechanism of the sexual organs or by disease of the central nervous system, syphilis, grave anæmia, systemic poisoning from lead, tobacco, etc., the prognosis is unfavorable, and we can hope to do little beyond arresting the course of the disease which is causing the trouble and, possibly, by building up the patient, we may restore to him some degree of sexual power. *Psychical* loss of sexual power offers probably the best opportunities for the use of aphrodisiacs. Most cases are due to nervousness, overwrought desire, indifference, grief, fright, and mental preoccupation.

If the case has its origin in nervousness caused by fear of the consequences of early abuse, the confidence of the patient must be obtained and moral suasion be used. He must be told to abstain from all sexual intercourse for ten days or two weeks and may be given a placebo which it is well to tell him will endow him with sexual strength, attention of course being paid to his general well-being. Those cases depending upon overwrought desire, frequently seen in newly married men after long engagements or sexual abstinence, are best treated by the *temporary* use of the bromides, together with suggestion. For these and for the remaining class of cases indications will be found for prescribing such general measures as hydrotherapy with massage, a diet consisting of highly seasoned food, red meats, and a moderate amount of alcoholic stimulants, and freedom from exhausting mental or physical work. Tonics may also be employed and the reputed aphrodisiac drugs, such as strychnine, in doses approximately of gr. $\frac{1}{30}$ three times daily, and phosphorus, gr. $\frac{1}{100}$ three times daily. Ergot is said to be of value in those cases of impotence which depend upon lack of erectile power, and among other drugs damiana, caffeine, and cantharis have some repute. The use of the last cannot be too strongly condemned, for if it aids sexual desire at all, which is doubtful at best, it does so by causing irritation of the genito-urinary passages and not by irritating or stimulating the nervous system. Other agents used are alternate applications of hot and cold water locally, electricity applied to the urethra or to the rectum, and the passage of a sound either reinforced by electric stimulation or by cold. But to repeat, impotence rarely if ever requires the use of aphrodisiac drugs, and success must come from moral force, general hygienic measures, and the removal of the cause.

Charles Adams Holder.

APHTHÆ. See *Mouth, Diseases of.*

APLASIA. See *Agenesia.*

APNŒA. See *Respiration.*

APOCODEINE—$C_{17}H_{19}NO_7$, is a reddish, amorphous powder, almost insoluble in water, soluble in alcohol, ether, and chloroform. The hydrochlorate of apocodeine is a grayish amorphous powder, very soluble in water. It is obtained by heating hydrochlorate of codeine for fifteen minutes with a concentrated solution of chloride of zinc, at a temperature of 170° or 180° C. On cooling, a yellowish-brown mass separates from the liquid. This is drawn in thin, silk-like threads, and is almost pure hydrochlorate of apocodeine. The preparation is easy, and there is yielded a much greater product than the morphine salt; it is also much more stable. The base may be obtained by precipitating it from a solution by the addition of carbonate of sodium and extracting with ether.

The reactions produced by reagents upon apomorphine and apocodeine are almost identical, with the exception that the blood-red coloration produced by nitric acid is much more permanent with the latter.

This drug has been introduced as an expectorant and emetic. The dose is from gr. $\frac{1}{30}$ to gr. i. It is recommended in the treatment of chronic bronchitis, croup, whooping-cough, etc. A one- or two-per-cent. solution may be prepared, and from five to ten minims administered. It acts rapidly, and the effect is prolonged. It may also be used hypodermically. *Beaumont Small.*

APOCYNACEÆ.—(The Oleander or Strophanthus family.) A great family of one hundred and thirty genera and more than one thousand species, very abundant in the tropics of both hemispheres, a few extending into the temperate zones. The plants are almost all trees or erect or climbing shrubs, with milky juice, and are highly ornamental and frequently cultivated for decorative purposes. The juices of Landolphia, Hancornia, and some others are utilized in the production of rubber. Valuable timbers are yielded by several species. The most noteworthy characteristic of the family is its poisonous nature, few other families being able to compare with it in this respect. Many of the species have been utilized as arrow poisons, and a number of these have been introduced into the materia medica. The active constituents are mostly glucosidal, commonly alkaloidal.

The action is chiefly upon the heart, stimulant in small doses, ultimately paralyzant, and thus frequently powerfully diuretic. Often, also, they are irritant emetico-cathartics. Their action is so powerful that even minute differences between them are of importance, and new remedies introduced from this family are always worthy

of careful attention. The important medicinal genera are strophanthus, aspidosperma, apocynum, and alstonia.

The poisonous principles are widely distributed through the plant bodies. *H. H. Rusby.*

APOCYNUM.—Canadian Hemp. "The root of *Apocynum cannabinum* L. (Fam. *Apocynaceæ*)." U. S. P. Up to a comparatively recent period the genus Apocynum was supposed to contain, in the Eastern United States, but two species, *A. cannabinum* L. and A. *androsæmifolium* L. As the latter was known to have but a weak physiological action, it was supposed to be necessary to exclude only this well-known species from the drug in order to insure its full properties. It is now known that the several supposed varieties of *A. cannabinum* are perfectly distinct species. *A. cannabinum*, therefore, as it has been understood and collected, is in reality several (probably four, at least) distinct species, the true *A. cannabinum* being apparently rather scarce. That some one or more of these species is a powerful and important medicine is indubitable, in view of the evidence presented; but in view of the numerous recorded failures, it is equally certain that not all of them are so. We are at present quite ignorant as to which is the active species, all statements of manufacturers, as well as the Pharmacopœia, to the contrary notwithstanding. The entire comparative study of these species is still before us. Under these circumstances any specific pharmacological account of the drug is out of the question.

The plants are erect, perennial herbs, growing by preference along railroads and roadsides. They propagate by long, horizontal underground structures, which appear to combine the characters of both root and stem. The latter is the part used. The aërial portion may be smooth or pubescent, and is usually purple or purplish. The leaves are opposite, oblong, or oval-ovate, thickish, mucronate. The stem is branched above and bears very small white or greenish-white flowers in close cymes. The fruit is a pair of long slender follicles, filled with small plumose seeds. The entire plant exudes an abundant milky juice.

The drug occurs in long, rather straight pieces, of about the thickness of a lead pencil and sparingly branched. It is of a brown color, having an orange shade if not old and stale. The bark exhibits few coarse wrinkles, finer nerves and coarse circular fissures. It is very thick, and pinkish-white internally. The wood is yellowish, very soft and brittle, its pores are large enough to be visible to the naked eye. It contains resin, tannin, starch, an amaroid, and the peculiar crystalline body apocynin, soluble in alcohol and poisonous, and the glucoside apocynein, soluble in water and of feeble action. The apocynin is a nauseating expectorant, and emetico-cathartic in over-doses, like the drug, but none of the constituents yet examined has an action exactly parallel with that of the drug. It is quite likely that they differ in the different species. Apocynum is a cardiac stimulant and a diuretic, as well as a nauseating expectorant. The most important use of the drug is in causing the removal of dropsical effusions. A fluid extract is official, the dose of which is 0.3 to 2.0 c.c. (♏ v. to xxx.). *H. H. Rusby.*

APOMORPHINE.—Apomorphine is an alkaloid derived from morphine by abstracting from the latter a molecule of water. This is done by heating it in sealed tubes with zinc chloride or hydrochloric acid. It may also be derived from codeine. It is commonly used in the form of the hydrochlorate, which is official. The Pharmacopœia thus describes it: "Minute, grayish-white shining, acicular crystals, without odor, having a faintly bitter taste, and acquiring a greenish tint upon exposure to light and air. Soluble at 15° C. (59° F.) in about 45 parts of water and about 45 parts of alcohol; very little soluble in ether or chloroform. When heated to near 100° C. (212° F.), the salt is decomposed, rapidly if in solution, slowly when dry."

The properties of apomorphine are totally distinct from those of morphine. It is primarily an emetic, acting altogether centrally, and with great promptness and power. It is secondarily an expectorant, increasing and greatly thinning the bronchial mucus. In poisoning, there is intoxication or delirium and paralysis of the motor nerves, with failure of respiration and especially of the heart.

In use, apomorphine is probably our most prompt and energetic emetic, its special value being the promptness and certainty with which vomiting can be induced by hypodermic injection when, for any reason, the stomach cannot be acted upon to produce it. As an expectorant, it is perhaps our most useful agent for relieving a "dry" cough. If given early, it will do much to avert bronchitis, and it is also especially useful in the hacking cough of tuberculosis. The emetic dose for an adult is gm. 0.006 to 0.01 (gr. $\frac{1}{10}$ to $\frac{1}{6}$); as an expectorant, gm. 0.0015 to 0.0025 (gr. $\frac{1}{40}$ to $\frac{1}{25}$). *H. H. Rusby.*

APOPLEXY. See *Brain Diseases: Hemorrhage.*

APPENDICITIS.—The term appendicitis is one that has come into general use of late years only, and, while occasional articles in the past have called attention to and well described that disease which now goes under the name of appendicitis, the general recognition and proper treatment of the same may be said to date from the well-known article by Fitz. It is true that inflammation of the cæcum, perityphlitis, and paratyphlitis are terms which express accurately the pathological condition in rare cases, yet inflammation in the right iliac fossa is known to be dependent upon some diseased condition of the appendix save in very exceptional instances. Hence the term "appendicitis" has displaced all others, to indicate inflammatory troubles, either acute or chronic, situated in the right iliac fossa.

The anatomy of the appendix is extremely varied. The organ is the remains of a portion of bowel which, during fœtal life, had much the same diameter as the rest of the cæcum, but at birth it presents an appearance which is accurately described by its name, worm-like appendage. It is attached by one extremity to the lower end of the cæcum into which its lumen opens, and a fold of mucous membrane, the valve of Gerlach, more or less covers the opening between the two portions of bowel. The attachment of the appendix to the cæcum will be found at the lower end of the cæcum, where the muscular bands so characteristic of the large intestine come together. Hence by following a muscular band of the colon and tracing it downward, one can reach the root of the appendix. The diameter of the appendix varies greatly. I have seen it an eighth of an inch in diameter; I have seen it dilated until its diameter was not less than one inch and a quarter. Perhaps a quarter of an inch would be not far from the usual size. The length varies as much as does the diameter. An appendix is mentioned in Dennis' "System of Surgery" as being nine and a half inches in length. I have seen it exist simply as a bunch of fibrous tissue not a quarter of an inch long, and between these two extremes the ordinary length will be found. The position of the appendix in relation to the cæcum will vary not less than do its length and diameter; and this is to be expected, since it is attached to the bowel by one extremity only, the other being more or less free. It may lie to the outer side of the cæcum and be turned upward, or behind the cæcum and be turned upward; it may also be so long as to hang over the brim of the pelvis and become an intrapelvic organ. It is surrounded partially by peritoneum. In rare cases it will be found lying entirely in the meso-cæcum, covered little or not at all by peritoneum. It has, under other conditions, a meso-appendix containing blood-vessels and lymphatics, as have the colon and other portions of the intestinal canal. The meso-appendix is rarely as long as is the appendix, to the tip of which it extends; hence this portion of the bowel is bent, sometimes acutely flexed, and thus it may become a cause of trouble owing to obstruction of the

lumen. It is probably very exceptional to find an appendix which is straight.

It is usual to consider that the appendix is histologically similar to the small intestine, namely, that it has circular and longitudinal muscular layers overlaid by peritoneum and lined internally by mucous membrane. The lymphatics from the appendix empty into the glands in the meso-appendix. The appendix is supplied by a rather large blood-vessel which extends to the tip of the organ, and does not at its termination anastomose with another vessel. Obliteration of this vessel at the cæcal end will therefore interfere with the blood supply of the whole appendix.

The healthy appendix feels to the touch as does the small intestine. When it is the seat of chronic inflammation, the appendix becomes firm to the touch and may be here and there pouched, or the lumen partially occluded, or, in exceptional cases, entirely closed.

The appendix contains normally mucus. Sometimes a little fecal matter, generally called "concretions," may be found in it, and exceptionally a foreign body.

The physiology of the appendix is unknown. In certain of the lower animals it is a large organ and undoubtedly assists in digestion. There is no reason to suppose that this condition of affairs exists in the human being. After the organ has been removed, or after its lumen has been obliterated, the human economy does not seem to suffer because of either of these conditions. In the female a fold of peritoneum extends from the right ovary to the appendix, and is invoked as a reason why inflammation of the right iliac fossa in the female may involve both organs.

The bacteriology of the appendix will not differ from that of the cæcum, with which it is in free communication; a perforation from the cavity of the appendix into the peritoneal cavity can be considered as a perforation of the cæcum, the colon bacillus being the organism on which the greatest stress is laid as a cause of the resulting inflammation and sepsis, though many organisms are found.

Appendicitis may occur at any time of life from youth to old age, but between the ages of ten and thirty the majority of cases are met with. Of the two sexes the male seems to be more often affected. In the female inflammation of the right tube may be mistaken for appendicitis.

It is usual to separate appendicitis into certain classes, the better to appreciate the pathological conditions present and the train of symptoms which one may be called upon to investigate; and while there is no hard-and-fast line between the different groups,—the division being purely arbitrary,—clinically such a classification will be found very helpful. Thus appendiceal colic, catarrhal appendicitis, suppurative, perforative, and gangrenous appendicitis are recognized as individual diseases of the appendix.

Chronic Appendicitis.

In the chronic form of inflammation the appendix has elastic, thickened, white walls and contracted lumen. To the touch the organ feels firm and stiff and more or less straight. An acute flexure exists rarely, for such a condition predisposes to an acute attack and to periappendicular inflammation. The whole appendix appears to be infiltrated with an exudate that usually does not invade the peritoneal coat, which retains its original shiny appearance; occasionally the appendix is adherent to adjacent organs by firm exudate, the evidence of one or more acute attacks. The meso-appendix may be thickened and firm, only in exceptional cases retaining its normal appearance. Whether the appendix lie entirely in connective tissue behind the cæcum, or be a peritoneal organ, its walls present when chronically inflamed the same general appearance. Attacks which accompany the condition of the appendix here stated vary in intensity and frequency. They may persist for years, occurring at irregular intervals, or they may occur at more or less frequent intervals, within a short time. Between the attacks the symptoms may disappear altogether, or there may be a sense of discomfort in the right iliac fossa, with recurring exacerbations. The terms relapsing and recurrent appendicitis are analogous to the terms remittent and intermittent malarial fever. The attack may be so slight as to be worthy of the name only of appendicular colic. Usually the term appendicular is omitted, by the patient at all events, and the term colic only used. It is very probable that a large number of cases of ordinary colic, called attacks of indigestion, are due to an appendicular sclerosis.

The symptoms which have been referred to as present in attacks of appendicitis will be noted, but to a minor degree, in the form of appenditis which is now under consideration. It is to be remembered also that attacks of chronic appendicitis may become perforative and therefore acute; this is the danger to be feared. With our present knowledge it is not possible to say when the next attack of appendicitis may occur and whether it may be of a serious character or not. Physical exploration of the right iliac fossa between the attacks may enable the examiner to localize the thickened and hardened appendix. Pressure upon it will cause discomfort, if not pain, and especially is this the case just prior to an attack and for some time afterward. The duration of an attack will vary; fever, constipation, etc., bearing a close relationship to the extent of disease present. After a few days, or perhaps even earlier, the symptoms diminish and the patient returns to his usual condition, only to be the subject of another attack later. There is always the chance that an attack of chronic appendicitis may become perforative, with results such as have already been stated.

Etiology.—No satisfactory cause of inflammation of the appendix is known. Traumatism, constipation, irregular development of the appendix, right tubal inflammation in women, indigestible substances taken into the stomach at meals, a superabundance of glandular tissue in the appendix, bending of the appendix whereby the lumen is mechanically obstructed, and many other reasons, are all put forward as the cause, probably with equal truth. Even the grippe, with which we Americans have been favored of late years, is suggested as a cause, although up to this time the organism peculiar to the grippe has not been discovered in causal relation with appendicitis, and epidemic influenza in the past does not seem to have given rise to appendicitis. The firm, stiff, elastic appendix, the subject of what we call chronic appendicitis, resembles scarcely any other pathological condition met with in the alimentary canal, and it does not seem to be so extraordinary a supposition that appendicitis, with its various terminations, may not be the pathological expression of a constitutional condition not yet recognized and named. Perforation of the appendix and the resulting peritonitis produce a change in the aspect of affairs not more marked than that which occurs after a perforation of the small intestine by a typhoid ulcer.

The complications met with in appendicitis have to do with the extension of the inflammation from the original seat of the disease to other parts of the body, not only through the lymphatic system, but also through the venous system. Among them may be mentioned thrombosis of the iliac vein, abscess in the liver (developed by way of the portal circulation), etc.

Foreign Bodies.—From time to time inflammation of the appendix has been attributed to foreign bodies impacted in the lumen of the tube—prune stones, date stones, grape seeds, etc. Examination shows that such so-called foreign bodies are usually masses of fæces more or less hard; and while foreign bodies are occasionally met with they are encountered very rarely. Probably the ordinary pin is the foreign body most frequently found. Not infrequently a fecal concretion is held firmly in the appendix, partly by the swelling of the surrounding mucous membrane and partly by the contraction of the circular muscular fibres. Under this pressure the concretion may gradually force its way

through the wall of the appendix. As to the cause of the impaction, nothing is known, nor do we know whether it is a common thing for fæces to enter the appendix and then pass out of it again.

PATHOLOGY.—Inflammation of the different coats of the bowel proceeds from within outward, the mucous coat being first affected, then the muscular, and finally the peritoneal. The ulceration involves a larger area of the mucous than of the muscular coat, and in turn a larger area of the muscular than of the peritoneal coat. The form of ulceration does not seem to differ from that which is met with in similar tissues elsewhere. As yet nothing specific has been discovered. Ulceration may occur anywhere within the interior of the bowel, on the side of the meso-cæcum or opposite to it, or at the extremity of the appendix. It is notable that as the ulceration deepens and involves the peritoneal coat, pain is experienced. When the peritoneal coat becomes involved, lymph is effused on the free surface of the serous membrane, and adjacent coils of intestine become adherent to the appendix, thus preventing in many cases extravasation into the peritoneal sac. If perforation occurs suddenly, the adhesions between the appendix and the adjacent coils of intestine may not be strong enough to prevent this extravasation; but if perforation occurs more slowly, these adhesions will probably be sufficiently strong to wall in firmly the extravasated material and the rapidly forming pus. A subsequent giving way of such an abscess into the general peritoneal sac is followed by a furious septic inflammation, which is general and almost necessarily fatal.

If the seat of ulceration and subsequent perforation occurs in a part of the appendix not covered by peritoneum—for instance where the appendix is turned behind the cæcum in the connective tissue—the perforation will simply give rise to a circumscribed abscess, into the formation of which peritonitis does not enter. Such an abscess will be in the meso-cæcum, and the tendency to perforation will be toward the loin rather than toward the peritoneal cavity. The periappendicular lesions will vary greatly in the two cases, the one giving rise to peritonitis, circumscribed or general, the other to a cellulitis, circumscribed always and general never. The situation is far less grave if the peritoneum is not involved, and the symptoms are less severe.

Pus having formed about the appendix and being walled in by the adhesions between this organ and the adjacent coils of intestine, does not remain quiet. It increases in amount and makes its way in the direction of the least resistance, sometimes in one direction, sometimes in another. The advance to the surface may be very slow: down the thigh, through the lumbar region, into the intestine, large or small, are the routes along which it may advance. When an abscess forms and exists for any time, the appendix will often be found floating in the pus, perhaps in its entirety or disintegrated. After the appendix has sloughed off fæces rarely are discharged—fecal-smelling matter yes, but fæces as such very rarely. The opening of the bowel usually closes without help on the part of the surgeon. It is difficult, from an examination before the operation, to state accurately where the appendix may be situated. I have seen it attached to the liver, which formed one of the boundaries of the abscess. I have seen it also in the scrotum, simulating strangulated hernia; in the left iliac fossa; and in the pelvis behind the rectum.

Left-sided appendicitis is not so very unusual and may occur from a transposition of viscera, from a long appendix, or from an extremely movable cæcum, which carries the appendix with it. The form of peritonitis which follows upon the perforation of the appendix will vary largely with the rapidity of the ulcerative process. Sloughing of the appendix and gangrene are more apt to occur when the seat of ulceration is near the cæcum, and possibly this outcome of the disease may be traceable to the obliteration of the nutrient artery of the appendix at the seat of the ulceration. Theoretically, at least, such a blocking of the nutrient artery near the cæcum would leave the appendix without vascular supply. This explanation, however, will not suffice for those cases in which the lumen of the artery is found not to be obstructed, and consequently one is forced to suppose that micro-organisms have to do with the production of the gangrene.

SYMPTOMS AND DIAGNOSIS.—If the inflammation involves the peritoneal coat and if it is accompanied by the formation of pus, the examination of the blood will show a leucocytosis more or less marked. In two of my recent cases, in both of which circumscribed suppuration within the peritoneal cavity existed, I found in one case a leucocytosis of 15,000 and in the other case one of 18,000.

So far as the differential diagnosis is concerned, it will be necessary to distinguish between the disease under consideration and renal or ureteral disease, inflammation of the gall bladder, typhoid perforation of the intestine, right salpingitis, abscess of the liver, tuberculous inflammation of the cæcum or mesentery, and intestinal strangulation. In a case recently under my care, which came to the hospital forty-eight hours after the commencement of symptoms, abdominal section showed that a Meckel's diverticulum had passed through a hole in the mesentery of the ileum, was strangulated, and gave rise to symptoms which justified the expectation of finding an inflamed appendix. While, then, in a majority of cases inflammation of the appendix, or of the immediate neighborhood, can be diagnosticated, in other cases abdominal section is necessary in order that accuracy of diagnosis may be arrived at.

Constipation.—Constipation is an unfavorable sign and can be taken to mean that some part of the intestinal wall is inflamed and consequently is not able to carry on its function properly,—namely, the transmission of fæces within the lumen of the tube. Such constipation may give way under the use of purgatives or enemata, but persists when inflammation is advancing. In septic peritonitis, when it is general, the constipation is absolute. So long as it is not present and the bowels act in response to the administration of purgatives, just so long may a favorable prognosis be given. Diarrhœa, in my opinion, is a vastly more favorable symptom than is constipation; indeed, diarrhœa does not occur as a symptom of appendicitis.

Muscular Tension.—The absence of motion which is noticed in the lower portion of the abdominal wall becomes more and more marked as the disease progresses, and this without the sufferer's knowledge. If the appendix is in the ordinary situation, the right rectus and the right oblique muscles will be somewhat more tense than are the corresponding muscles on the other side (left) of the body; this being probably more marked in the case of the rectus than in that of the oblique muscles. Flexion of the right thigh has been referred to below, under the head of attitude. This position of the limb suggests that the appendix is situated behind the cæcum rather than in front of it, and it may be so marked as entirely to incapacitate the patient from extending the limb. Muscular tension on the front of the belly disappears when a paresis of the intestinal wall from general sepsis takes place. This is not seen early in an attack. The belly wall then balloons out and justifies an unfavorable prognosis. The abdominal walls may be extremely tense, flat, and board-like. This condition, which is not met with in simple acute appendicitis, is a very unfavorable symptom, and indicates the existence of an acute peritonitis due to the giving way of the wall of the intestine and the extravasation of bowel contents. It is accompanied by high rectal temperature.

Breathing.—The breathing is usually accelerated, and becomes more so as inflammation advances. If the peritoneal coat of the appendix is involved, the patient's breathing will be largely thoracic. Respiratory movements of 22 to 24 per minute may be expected when an acute inflammation is present, and the abdominal wall over the inflamed area will be quiet if not motionless, the breathing being therefore somewhat short. When much peritoneal membrane is inflamed, the belly wall

below the navel will be quite still, and this lack of motion can be considered a symptom of gravity. Hiccough is not present in the early stage of inflammation, and when seen later it must be regarded as a grave symptom.

Auscultation.—Auscultation enables one to recognize that movements of the bowels are taking place, the gurgling of gas and other sounds being easily perceptible. Absolute silence over the belly, on auscultation, is an unfavorable symptom; it suggests intestinal paresis, and justifies a most grave prognosis.

Attitude of the Patient.—The patient will take the attitude which puts the inflamed portion of the body at rest; hence the recumbent position, the flexed right thigh, the removal of all compressing bands or substances which weigh upon the belly, and the absolute quiet which he maintains. The flexion of the thigh shortens the psoas and iliacus muscles which are adjacent to the inflamed area; and, to effect a still further shortening, the knee may be grasped and the thigh pulled toward the body. The facial expression varies greatly; the general expression is one of anxiety and uncertainty, and this expression becomes more and more pronounced as the disease advances. In septic peritonitis the Hippocratic countenance occurs. A flushed face, dry lips, etc., accompany fever, but the typhoid expression is not characteristic of an acute attack of appendicitis.

The Intelligence.—The intelligence of the patient is not affected; it is often very acute, and persists, notwithstanding the many changes in the disease, until shortly before death. Even when general sepsis is present, the acuteness of mind and intelligence may persist. Dark circles around the eyes and an apparent recession of the eyes into the orbits may be taken to indicate that peritoneal inflammation is serious and advancing.

Pain.—Pain commences suddenly; it may amount only to discomfort or it may be acute, even to the extent of incapacitating the patient from moving or seeking help in any way. While the pain may be severe the acme is not reached for a certain time. At first the pain is referred to the epigastric or umbilical region, but later it seems to shift, and the patient will refer it to the region of the appendix. Rarely is this noticed until some hours after the commencement of suffering, unless perforation takes place; but, sooner or later, pain in the region of the appendix is to be expected. It is perhaps noteworthy that while dry warmth, as a bottle of hot water or hot flannel, may relieve pain, the patient will never make pressure over the tender region; indeed, pressure increases suffering, a circumstance which distinguishes this disease from the colic of indigestion. Pain may be felt in the lumbar region, and this is especially noticeable when the appendix is behind the cæcum. The writer has noticed in chronic appendicitis, when discomfort was referred to the epigastric region, that support by a bandage applied to the right iliac fossa has sufficed to remove the epigastric pain. If the appendix is long and the inflamed end is in relation with the urinary bladder or ureter, pain in micturition and pain referred to the meatus are complained of, the latter being possibly acute. The desire to pass water frequently is then complained of. When the appendix is on the left side, or is so long as to extend to the left side, and becomes there inflamed, pain, as would be expected, is referred to that region. McBurney has called attention to the fact that pressure pain is most marked in many cases at a point situated two inches to the inner side of the anterior superior spinous process on the right side, along a straight line drawn from that process to the navel. At or about this place is usually situated the root of the appendix. If the inflamed organ lies anterior to the cæcum, the pain is more acute on pressure; but if it is behind the cæcum, deep pressure may be necessary to elicit an expression of pain, unless the peritoneal coat is already involved. When the end of the inflamed appendix hangs over the brim of the pelvis, deep rectal examination may give pain. It goes without saying that when the peritoneal coat of the appendix is implicated in an inflammatory process, absolute rest is comfortable to the patient; hence whatever muscular effort will in any way relieve the movement of the abdominal muscles is unconsciously made use of by the patient. Thus, for example, while the lower abdominal wall, especially on the right side, will be quite still, it will be observed that the patient does his breathing by means of the thoracic muscles. As more and more peritoneal membrane becomes involved in the inflammatory process, so the pain becomes more and more extended, diffuse, and acute. Hence a fair knowledge of the amount of peritoneum involved can be obtained from the patient's expression of pain when pressure is made over different parts of the abdomen. Pain in the right iliac fossa, in the epigastric region, under the left ribs, in the rectum, may indicate that a general peritonitis is present. Pain in the right flank suggests the presence of the appendix behind the cæcum, or of matter tending to point in that direction. Should pain in the right iliac fossa in front be wanting, the opinion just expressed would be rendered wellnigh certain. A sudden disappearance of all pain, when taken in connection with the advance of the symptoms and with the great weakness, makes the prognosis very grave.

Vomiting.—Vomiting is often met with during the onset of an attack and may be taken to indicate severity. The material vomited will be that which the stomach contains; afterward, it will consist of mucus, perhaps bile-stained; but the so-called stercoraceous vomiting of strangulated hernia is not seen. Vomiting may be excited by taking substances into the stomach—water, food, etc., but it rarely persists beyond the onset of the attack. When general septic peritonitis exists, vomiting resembles regurgitation, and the material regurgitated will look like finely chopped spinach, so green will it be

Pulse.—The pulse rapidly rises and the rapidity bears a close relation with the amount of inflammation present. In cases in which the attack is very sudden and the peritoneal coat is rapidly involved, the pulse increases with amazing rapidity. A rapid, full pulse suggests an advancing and perforative inflammation, especially if the rapidity continues. Perforation is characterized by a very rapid, feeble pulse. The pulse is a better index than the temperature, unless this latter is taken by both rectum and mouth and the two are compared. When death is impending and in rapidly advancing cases, the pulse will disappear from the wrist some time before dissolution.

The pulse seems to bear a close relation with septic absorption

Fever.—The amount of fever apparent when the temperature is taken with a thermometer in the ordinary way, is deceptive. By the mouth or the axilla the temperature may be normal or subnormal. It is not at all unusual, especially when perforation of the bowel has taken place, for the surface temperature to be subnormal and the skin clammy and pale. In acute appendicitis the only bodily temperature that is worth considering is that which is taken by the rectum; and by this I do not mean the temperature which is taken just within the anus, but the temperature which is taken four or five inches above the anus, at or about the point where the peritoneum is reflected on to the rectum. The temperature by the mouth should be taken and compared with the temperature by the rectum. A difference of several degrees indicates peritonitis.

When the temperature of the mouth and that of the rectum are nearly the same, general peritonitis can be excluded. The temperature of the rectum then can be taken as a fair index of the gravity of the patient's condition. It is usual to consider that the pulse is a better index of the patient's condition than the temperature, but when the temperature is taken by the rectum and compared with the temperature by the mouth, valuable information is gained by the physician. A rectal temperature of 102.5° or 103° F. strongly suggests circumscribed suppuration about the appendix. It will be one or two degrees higher than by the mouth. A general peritonitis not walled off by adhesions will usually give a rectal temperature of 104° F. or higher.

A subnormal temperature by mouth or axilla, especially if the skin is pale and pulse rapid, suggests a determination of blood to the peritoneal cavity and always necessitates that the temperature be taken by rectum. An advancing temperature always suggests an advancing inflammation, but the absence thereof does not mean that the inflammation is at rest. A chill rarely occurs unless the peritoneum is involved and suppuration is imminent. The chill may be of such a minor degree as to attract no decided notice on the patient's part. The patient will sometimes complain of a little chilliness in the back, or ask that an adjacent window be closed, but a severe chill is exceptional. Chills at short intervals can be taken as a symptom of constitutional sepsis, rather than of local inflammation.

Subsidence of the temperature, when associated with slowness and strength of the pulse, is a good sign and indicates a favorable change in the patient's condition. It will be noticed during an attack of colic, and it suggests the removal of the cause that gives rise to the colic. When catarrhal inflammation of the appendix exists, there will be a free discharge of mucus into the cæcum; and when suppuration exists within the appendix, the disappearance of pain will indicate that the contents of the appendix are being emptied into the cæcum and that consequently the tension has diminished.

Perforative Appendicitis.

Symptoms.—The symptoms which characterize perforation with extravasation into the general peritoneal cavity are marked. There occurs generally a sense as of something giving way followed by excruciating pain and pronounced collapse. The patient experiences a sense of profound illness or even of impending dissolution; he is restless and his voice is feeble and sighing. The surface becomes cold and clammy, the pulse very frequent and feeble, the skin pale and covered with sweat, the muscular system relaxed. The temperature at this time is subnormal upon the surface and in the mouth; in the rectum it is several degrees higher. If the extravasation is small and can be circumscribed, adjacent coils of intestine adhere together, and symptoms of an abscess within the peritoneal cavity appear. If the inflammation is general and not circumscribed, then in addition to peritonitis the symptoms of general septic absorption become plain. The rectal temperature goes to 104° or 105° or 106° F., the pulse rises gradually until it can no longer be counted, the abdomen either becomes boardlike from the rigidity of the muscles or else balloons out (intestinal paresis). Auscultation shows no movement in the bowels. Tumefaction, formerly apparent in the right iliac fossa, disappears. A finger pressed on the skin leaves a white mark which disappears slowly, and the eyes are surrounded by dark rings and seem to recede in their sockets. Constipation is absolute, urination infrequent; the patient is thirsty and craves crushed ice; the tongue becomes dry; advancing restlessness is very apparent; intelligence is usually and unfortunately acute. Gradually the extremities become chilly and then cold, the pulse disappears from the periphery to the centre, and death closes the scene.

Prognosis.—When the fever is not high and does not advance rapidly, when the pulse is full and not very fast, when the bowels are moved by mild purgatives, when the abdominal walls are not hard or rigid during respiration, when tenderness in the right iliac fossa is but slight, when vomiting has occurred perhaps once or twice only, when the patient sleeps without narcotics and experiences little general discomfort, and when the expression of the face does not indicate peritoneal inflammation, it may safely be said that an operation need not be undertaken immediately, and that medical means may be employed. When the pulse grows more rapid and the temperature rises steadily, when pain and discomfort increase, when rigidity of the abdominal wall is present and is becoming more marked, when pain in the right iliac fossa is more apparent than some hours previously, when the bowels are constipated, it is to be recognized that the disease is advancing. With a rapid pulse, flushed face, high rectal temperature (that in the mouth being moderate), pain decided in the right iliac fossa and much increased on pressure, firmness of the abdominal walls and immobility of the parts in the right iliac fossa during respiration, and a leucocytosis present, it may be said with some decision that suppuration is present outside of the appendix. A very rapid, feeble pulse, a temperature of 103.5° to 105° F. in the rectum, elevated only a degree or two, perhaps subnormal, in the mouth, a pale skin, finger pressure on the skin making a white discoloration which slowly disappears as the blood returns in the capillaries, board like abdomen or a ballooned out abdomen, urine in scanty amount, with or without a hardness in the right iliac fossa, and tenderness on pressure over the whole abdomen, justify a diagnosis of a general peritonitis and a very unfavorable prognosis. If, added to the above symptoms, the pulse cannot be counted at the wrist, the extremities are cold, and there is lividity about the mouth, ears, and over depending portions of the trunk, dissolution may be held to be not very far distant

Treatment.—The treatment of appendicitis is to be considered in relation to the pathological condition present. It may be accepted that an inflamed appendix is not in its proper place when situated in the human body, and the sooner it is taken away the better, in order that the patient may have no more acute attacks and that the attack then present shall be cut short. So much for the general statement. But, unfortunately, this treatment, while it is good in general, will, in a certain number of cases, undoubtedly cause the death of the patient.

Medical Treatment.—In view of the evidences of previous inflammation about the appendix found post mortem, it is plain that many cases of appendicitis recover not only without operation but without treatment; and it goes without saying that surgical treatment is unnecessary in many instances, medical treatment sufficing to produce a cure—or, at all events, if not a cure, an amelioration of the inflammatory conditions existing, so that an operation between attacks is possible.

The medical treatment for appendicitis can be briefly summed up as follows: absolute rest in the recumbent position, abstinence from food, dry cold in the form of a rubber bag or bladder filled with ice kept over the right iliac region, and free purgation. The use of opium has not been beneficial in my hands, and I abstain from using it until the pathological condition of affairs in and about the appendix is plain. Where doubt exists opiates are contraindicated. I have not been able to see that free purging has ever done any harm or that it has induced a giving way of the appendix wall which otherwise might not have been expected; hence rest to the body and free purging are mainly to be relied on. Intense and agonizing pain in the region of the appendix should lead to operation rather than to the administration of opium. An additional reason for withholding opium is that by deadening the sensibility, the important symptom, pain, is rendered uncertain; and it is a very important symptom, often enabling the surgeon to recognize the condition of affairs present. Opium also constipates. Pain and inflammation occurring in the right iliac fossa accompanied by constipation justify a much graver prognosis than does the same amount of inflammation, if purging can be induced easily. When it is necessary to induce sleep, chloral in large doses, by the rectum if there is vomiting, can be given. Some of the coal-tar derivatives also may be used; but it is not wise to obtund sensibility and to produce constipation by drugs until the condition of affairs is quite evident. If opiates are given before an operation, the bowels will remain constipated after the operation, and so there is brought about a condition of affairs unfavorable for recovery.

Surgical Treatment.—In acute appendicitis, when the disease is limited to the appendix itself, the periappendicular tissue being but little involved and the appendix not yet perforated, if it is possible for the surgeon to

recognize this condition of affairs as present, it is unquestionably proper at once to remove the appendix. With modern methods the danger attending abdominal section and the removal of the inflamed appendix—the inflammation, however, not having extended to the peritoneal coat—is small, and incomparably less than when the appendix is allowed to remain. Furthermore, it is proper to do the operation immediately. Unfortunately, it does not often happen that the surgeon sees the case at this stage of the disease, because the patient may have been treated by a physician until this time has passed, or because the disease has passed beyond this stage before the patient has called attention to the trouble. Not infrequently the patient's attention is seriously attracted for the first time to his or her condition only when the peritoneum becomes involved, *i.e.*, when the pain becomes severe and the fever marked.

The following case is an example: A girl, aged nine, while at dinner with a friend, was taken with an acute pain in the abdomen. She left the table complaining, and went home. She vomited during the evening, and went to bed, suffering much pain. I saw her the following morning. There was then acute pain in the right iliac fossa, extending somewhat across the middle line of the body. Temperature by the rectum was 103.5° F., pulse 118, face flushed, thirst was complained of. I at once opened the abdomen, finding a ruptured appendix and a piece of fecal matter in the peritoneal cavity. Decidedly less than a day had elapsed since the first symptom of discomfort or illness had been complained of by the child. It is probable that in this case the occurrence of a perforation gave rise to the first symptoms recognized by the child and that ulceration of the mucous membrane of the appendix and of the muscular coat had been going on for some time without the patient's discomfort or knowledge. The child, up to the time of its attack at the dinner table, had been in active, vigorous health, to all appearances, and had been enjoying all the sports of childhood. Inasmuch as perforation, when it takes place during the first two or three days, is not so apt to be walled in by adhesive peritonitis as when perforation takes place at a later period, it is wise to remove the appendix and cut short the disease during these first two or three days—*i.e.*, providing the disease is advancing—lest general peritoneal inflammation supervene. In the acute cases this is the most favorable time for operation. Later, when pus forms about the appendix, there is then to be considered, not only the disease of the appendix, but also in addition an abscess which is walled in by the adhesions of coils of intestine, for the abscess is very generally intraperitoneal. In exceptional cases, in which the appendix lies behind the cæcum in connective tissue, the abscess is found to be extraperitoneal. Although it occupies a position behind the serous membrane, the tendency there, as has been already pointed out, is for the pus to move toward the loin.

The treatment of appendicitis associated with periappendicular intraperitoneal abscess is a subject of great moment and one in which it is not possible to lay down definite rules of practice, more particularly in regard to the precise time when the pus is to be evacuated. The danger is, that the general peritoneal cavity may become infected, and that a general septic peritonitis, with all its grave results, will follow. The appendix itself, which is the cause of the trouble, is perforated, or, at all events, if not actually perforated, it is unquestionably in that condition of inflammation which permits the passage through its walls of the organisms within its lumen. Under such conditions it is clear that the appendix itself should be removed. The abscess, with the tissues immediately surrounding it, should also be removed, and the peritoneal cavity should be rendered thoroughly clean. But just here we encounter a serious difficulty. The manipulations necessary to accomplish the desired purpose may cause a rupture to take place in the softened tissues and thus may lead to a general infection of the peritoneal cavity. When pus exists in this cavity it is imperative that effective drainage should be provided. This may be provided either by strips of gauze or by some form of tubes. My personal preference is, in the majority of cases, for gauze; I use tubes very rarely and only in conjunction with gauze, or when gauze has shown itself to be a failure. It may be extremely difficult, when an abscess is present, to find the appendix, so buried will it be in the wall of the abscess. Is it right to search for and remove a diseased appendix, no matter what difficulty the operator may experience in searching for it, or to what extent he may open and infect a clean peritoneal cavity? Probably the best rule for the surgeon is to open freely the abdomen, evacuate the periappendicular abscess, search for the appendix carefully, and remove it unless such search and removal shall actually threaten to infect the hitherto uninfected peritoneal cavity. After evacuation of the pus, fill lightly the abscess cavity with gauze, which should be in strips and should project beyond the skin of the abdomen, thus serving as a drain.

Sometimes it will be found that the appendix has already sloughed off from the cæcum, and is lying free in the abscess cavity, or it may be washed out with the pus during the first few days following the operation. At times a little fecal matter appears in the discharge, and yet, notwithstanding this, the perforation may close without the necessity of suturing or applying a ligature. I do not think it wise to wash out with water the cavity of an intraperitoneal abscess at the time when it is first opened. Immediately after such opening the pus is to be evacuated and gauze is to be packed lightly in the abscess cavity, but no irrigation is to be made use of. This course is advocated because irrigation, even when effected by means of a gentle stream, may separate adhesions and so transport pus to the previously healthy general peritoneal sac. After a few days the adhesions will have become stronger and then general irrigation may be not only permissible but necessary, in order to cleanse the cavity. Irrigation under strong pressure is never expedient. When general septic peritonitis exists, no harm can follow the separation of adhesions, if such a step is found to be necessary in searching for the appendix or for outlying collections of pus. The general peritoneum everywhere is to be wiped with gauze until all pus and lymph shall have been removed, and gauze strands, many in number and of large size, should be packed among the intestines so as to drain from every direction. I am not enthusiastic in regard to the practice of employing large quantities—gallons—of water in washing out the general peritoneal cavity, as is advocated by some excellent surgeons. The results which I have obtained without such copious irrigation will compare favorably, I believe, with those obtained by the advocates of this procedure. The danger here, as it seems to me, lies in the possibility of infectious material being carried by the water to parts previously free from infection.

By way of preparation for the operation the entire abdomen should be shaved and cleansed, and the cleansing process should extend on the right side as far as the spine, for there is always a possibility that drainage through the flank may be required.

McBurney has called attention to the advantages offered by an incision in the line of the fibres of the external oblique muscle, an inch or two internal to the anterior superior spinous process of the ilium, and long enough to enable one to gain access to the belly. The middle point of this incision should fall upon a line drawn from the navel to the anterior superior spinous process. The incision having been made, the external oblique tendon should be split in the line of its fibres and its muscular fibres should be separated in the same way. When the edges of this incision are well retracted, there comes into view the internal oblique and then the transversalis, with fibres running at right angles to the skin and external oblique incision. These internal oblique and transversalis fibres are to be separated by scissors or knife, but not cut across. By retracting these two muscle layers in opposite directions access is given to

the peritoneal cavity, and in many cases it is possible through this incision to operate satisfactorily. No fibre of muscle has been divided, and after the operation the integrity of the belly wall is restored. When suppuration has taken place outside of the appendix, and more room is needed, this incision can be prolonged to give sufficient room: first, by separating the external oblique fibres over a longer distance, the skin incision of course corresponding; and, secondly, by extending the (deep) transverse incision so as to divide the anterior and posterior sheaths of the rectus. The epigastric vessels are easily seen and are to be tied with two ligatures and then divided. The muscle itself is not to be divided, but is to be drawn toward the median line by retractors. By extending McBurney's incision, therefore, the surgeon will obtain ample room for further operative work, except perhaps in cases of exceptionally large inflammatory areas around the appendix. The fascia under the transversalis and the peritoneum are to be opened to an extent justified by the necessities of the case. Should there exist a periappendicular abscess in front of the cæcum, the connective tissue outside of the peritoneum under the transversalis will be œdematous, and if the inflammation be great, œdematous connective tissue will be noticed as soon as the tendon of the external oblique muscle is divided. When the inflammation is confined to the appendix, one or two fingers put through the peritoneal incision will enable the operator to hook up the appendix, which can be drawn into the wound and removed. There is no necessity for making a very small incision. If the excellent advice of McBurney in regard to separating, rather than cutting across, muscular fibre has been followed, the integrity of the abdominal wall is assured after operation.

I find the removal of the appendix is best done as follows: After it has been drawn into the wound, the peritoneal cavity is to be walled off by gauze and the meso-appendix tied off, if voluminous, in segments; if not voluminous, by a single silk ligature. The peritoneal and muscular coats of the appendix are next to be cut circularly at a distance of about one-fourth of an inch from the cæcum, but the incision is not to be extended through the mucous membrane. The muscular and peritoneal tissues are then pushed back, away from the mucous membrane, until the cæcum is reached. An assistant should now grasp this denuded cylindrical tube of mucous membrane by means of two slender artery forceps, while the surgeon makes the dividing incision between the forceps. The free appendix is then to be removed, and the proximal end, close to the cæcum, well touched with pure carbolic acid. The operator may tie the appendix stump, if he feels inclined, but patients seem to do as well without such tying as with it. The stump of the appendix is to be turned into the cæcum, and the peritoneal surfaces of the appendix cuff are to be brought together by means of a Lembert suture, thereby invaginating the stump. If there is any doubt as to what is the condition of affairs, the operator may pass a probe into the cæcum after removal of the artery forceps from the mucous membrane of the appendix, but this, it seems to me, is needless. The wall of the cæcum having been united over the invaginated appendix stump, the same Lembert suture is to be employed in closing in the stump of the meso-appendix. Nothing but peritoneum is then visible. The operator may apply additional sutures to the peritoneal surface, if he feels so inclined. As a rule it is my custom to do this. The wound is cleaned and wiped with gauze, and the gut is pushed back into the abdominal cavity. The peritoneum is then sutured with fine silk, and the two layers of muscle are united separately with silver wire or other material, as the operator prefers. Finally, the skin edges are brought together. Silkworm gut or silver is my preference here. When a periappendicular abscess exists, and I find it necessary to drain the cavity, I bring the ends of the gauze to the surface for drainage, and I close the edges of the wound lightly with layers of removable sutures; for when drainage is employed, my buried sutures are apt to become infected and to give trouble, as drainage precludes absolute cleanliness. If the appendix is swollen and stiff and cannot be invaginated, it is a good plan to tie a string around the base, to cut off that part of the appendix which is distal to the string, and then to leave the string to come away with the gauze packing with which the abscess cavity is lightly filled.

It is very comfortable for the operator to know that the appendix has been removed and that that source of trouble is eliminated from consideration. Whenever, therefore, it is possible to do so, the appendix is to be taken away. But it cannot be done in a certain number of cases without serious danger to the patient; hence in such cases it must be left. Sometimes no trouble is ever experienced from an appendix which has not been seen; but in other cases it may be necessary to do a second operation for the removal of the appendix. An operation is incomplete without the removal of the appendix, but the incompleteness of the operation is less dangerous than is the search for the appendix and the consequent tearing up of adhesions, with possible general infection.

A second operation is undertaken when the inflammatory area is in a quiescent state. Secondary operations and those undertaken for chronic appendicitis are very successful. When general septic peritonitis is present, free opening of the belly is necessary, for the preservation of life takes precedence of every other consideration. Hence the opening into the belly will be effected by an incision sufficiently long to enable the operator to reach all the seat of disease. Pus and fæces are to be evacuated; the whole peritoneal cavity is to be carefully cleaned, dry gauze or gauze wrung out in hot salt solution being used for the purpose; any lymph that may be present should be removed when possible; and it may be thought best (although I have not done it) to wash out the peritoneal cavity. Hot salt solution of course will be employed for this purpose. I think I have had as good results by using dry gauze, or gauze wrung out, as stated already, in hot salt solution. The places where pus must be sought for and removed are the following: the outer side of the ascending colon, below the liver, the pelvic cavity, the side of the rectum, and between the folds of the small intestine. If necessary, the intestines are to be taken from the belly cavity, wiped and cleaned outside, but much shock follows such evisceration. The pelvis is the region which specially requires to be examined and cleaned. After the peritoneum has been cleaned, I think the recovery of the patient is aided by laying large strands of gauze in every direction in the abdomen, as has been already referred to. The edges of the incision are to be left wide open. There is scarcely a limit to the number of strands of gauze which a general peritoneal infection may call for. It may be wise in some cases, in order to provide more direct drainage, to make an opening at the back of the belly through the lumbar region.

In general septic peritonitis the bowels usually refuse to act, and, when this is the case, it may be well, as was first suggested by Dr. McCosh, of New York, to inject into the upper part of the small intestine, before the abdomen is closed, a couple of ounces of Rochelle salts dissolved in water. In order to accomplish this it will be necessary first to pass a small cannula through the intestinal wall. Then, after all the solution has been injected, the hole made by the cannula can be closed by a single Lembert's suture.

Operation for Chronic Appendicitis.—The best time for operating, in a case of recurrent attacks of appendicitis, is during the interval between two attacks, say two or three weeks after the subsidence of the first of these two, provided it has not been an attack of unusual severity. In the latter case the operation should be deferred for a somewhat longer period. The reason why an operation should not be done sooner is that sufficient time must be allowed to elapse in order that any periappendicular lymph may be absorbed, that any pus that may have collected within the appendix may have time to escape

into the cæcum, and finally that any remaining inflammation may subside completely before the abdomen is opened. It is interesting to note that when inflammation has been excessive, an operation undertaken a number of weeks afterward will find the adhesions thin and weak. It may be expedient to wait even longer, but such a waiting should be permitted only when the patient is directly under the eye of the surgeon, who can intervene at any moment, should another attack occur.

As the steps of the operation have already been described, it will not be necessary to go over this ground a second time. I will simply add that in these chronic cases, especially if the inflammatory attacks have been of a somewhat severe character, it is often a difficult matter to find the appendix, or, if we do find it, to recognize at what point its free end lies. In such cases, the shortest way is probably to divide the appendix across, between two pairs of artery forceps, and then to work each end free from adhesions. In this way there will be no special difficulty in reaching the point where the appendix springs from the cæcum. Whenever this can be done we should cover raw surfaces over with peritoneum.

L. McLane Tiffany.

APYONIM.—This is a yellow, crystalline powder, introduced as a substitute for auromine (yellow pyoktanin) in ophthalmic practice. It is slightly soluble in water, freely so in alcohol, and it is used in one-per-cent. aqueous solution as an antiseptic and stimulant in conjunctival disease, and in purulent keratitis.

W. A. Bastedo.

AQUIFOLIACEÆ or **ILICINEÆ.**—(The Ilex or Holly family.) A family of three genera and some two hundred species, chiefly of North and South America. It is chiefly notable for the presence of an appreciable amount of caffeine in the leaves of at least two species, on account of which they have been used as beverages (see *Maté* and *Cassine*). Other species have been used as bitter tonics and alteratives (see *Alder*, *Black*, and *Holly*).

H. H. Rusby.

ARACEÆ or **AROIDEÆ.**—(The Arum family.) A large family, of more than one hundred genera, growing mostly in the tropics of both hemispheres. Many species, as the cultivated *calla*, are highly ornamental. *Colocasia* produces an important starch-yielding corm, *monstera*, an edible fruit. Many of the tropical species are known as poisons, but their constituents and actions are little known. It is remarkable that a few northern species in the genera *spathyema*, *acorus*, *arum*, and *arisæma*, should represent about all the medicinal contributions of the family, and more active agents may be expected to be made known in it in future.

H. H. Rusby.

ARACHNIDA.*—In the branch or phylum Arthropoda, characterized by bilateral symmetry, by metameric segmentation of a heteronomous type, and by the possession of jointed appendages, typically a single pair for each metamere of the body, may be distinguished five great groups: the Crustacea, including crabs, lobsters, water fleas, etc.; the Onychophora, including but a single genus, Peripatus; the Myriapoda, including millipeds, centipeds, etc.; the Insecta, including the true insects; and the Arachnida or Arachnoidea. The latter may be defined as air-breathing arthropods, characterized by the fusion of head and thorax into a single region, the cephalothorax, which is without antennæ, but bears two pairs of appendages more or less closely connected with the mouth, and four pairs of walking legs. The abdomen, which may or may not be segmented, is usually distinct from the cephalothorax, though in the mites it is fused with it.

The class Arachnida is subdivided by various authorities into from seven to nine orders, among which are the Scorpionida or true scorpions, the Pseudoscorpionida or book-scorpions, the Phalangida or "Daddy Long-legs," the Araneida or true spiders, the Acarida or mites, and the Linguatulida.

The true scorpions have the power to inflict a painful wound by the sting located at the tip of the abdomen. In the case of large tropical species the effect of the sting may even cause the death of small children, but only in the most exceptional cases does it seriously affect an adult. There is injected at the time a quantity of poison from a gland in the last joint of the abdomen; its action is in general to irritate nerve centres while at the same time producing paralysis of motor nerves. The sting of the smaller species found in the United States is harmless, giving rise to a slight irritation, which lasts at most seven or eight days. Mr. Herbert H. Smith, the well-known collector in South and Central America and the West Indies, after enumerating symptoms and results in a number of carefully observed instances, says: "Probably death might result in some cases, as (if reports are true) it does, rarely, from bee stings. . . . My wife was stung by a small one; the wound was exceedingly painful. By the advice of a servant, she held the finger for an hour in hot sweet oil, mixed with an equal measure of laudanum. There was no swelling and three hours after all pain had left her."

Among the spiders also there are those that are able to pierce the human skin by the action of the jaws or chelicerae which also contain the orifices of a pair of poison glands. The effect of a spider's bite on an adult has, however, been much exaggerated; of itself the bite produces at most a slight dermal swelling which soon disappears. The large hairy theraphosids, popularly known as tarantulas, are not to be called dangerous. Their bite is painful, but the inflammation, though often violent, subsides rapidly. On the other hand, several cases on record of death from spider's bite have been traced to a small spider (*Latrodectus mactans*) which is related to supposedly poisonous species in other countries of the world, and it is not unlikely that the spiders of this genus secrete a more powerful fluid than others. The condition of the patient, his susceptibility to poison, and other important facts are not on record in these cases, and it may happen that the chance introduction of extraneous matter through the bite has given rise to the more serious and rarely to the fatal results noted. There are no spiders in this country of which it may positively be affirmed that they are venomous, though certain South American species enjoy an evil reputation which is undoubtedly well founded.

Order LINGUATULIDA.—The highly modified forms included in this group have a certain superficial resemblance to tapeworms, from which, however, they differ radically in structure. Their closest affinities are doubtless to be found among the arachnids of which they are here considered as an order.

FIG. 243.—Ling[illegible] tula rhinar[illegible] female. Natu[illegible] size. (Aft[illegible] Braun.)

The body (Fig. 243) is elongate, cylindrical or flattened; the anterior end (cephalothorax) is more or less clearly marked off from the rest (abdomen), which is subdivided by annulations variable in number and distinctness. A[illegible] the blunter, anterior end the mouth is located on [illegible] the ventral surface and provided on either side with t[illegible] two protractile hooks, contained in sheaths or pocke[illegible]ets. These hooks represent the mouth parts of other arachni[illegible]ids,

* A general discussion of parasitism and its effects will be found under the heading *Parasites*.

the egg emerges a hexapod larva which metamorphoses into an octopod nymph, and finally by the development of the sexual organs becomes adult. This metamorphosis is accompanied by a variable number of moults, and in the Sarcoptidæ by histolysis and complete regeneration of the animal at each ecdysis.

The following table, taken from Railliet, will be convenient in recognizing the various sub-orders and families:

Body elongated. **Vermiformia.**	No tracheæ. Legs with epimeres.	Two pairs of legs. Palpi unarmed. Mandibles styliform.	Phytoptidæ.
		Four pairs of legs. Palpi uncinate. Mandibles styliform.	Demodicidæ.
Body compressed. **Acarina.**	No tracheæ. **Astigmata.** Legs with epimeres.	Palpi joined at base, unarmed. Mandibles chelate.	Sarcoptidæ.
	Tracheæ opening in the anterior portion of the body, atrophied in the aquatic forms. **Prostigmata.** Legs with epimeres.	Palpi free, unarmed, antenniform. Mandibles chelate.	Bdellidæ.
		Palpi free, armed (rapaci). Mandibles with hooks, or styliform.	Marine: Halicaridæ. Freshwater: Hydrachnidæ. Terrestrial: Trombidiidæ.
	Tracheæ opening in the posterior portion of the body, at the base of the legs, sometimes atrophied. **Metastigmata.** Legs without epimeres.	Palpi free fusiform, mandibles chelate.	Oribatidæ.
		Palpi free, filiform or valvate. Mandibles, pseudo-chelate.	Ixodidæ.
		Palpi free, filiform. Mandibles chelate.	Gamasidæ.

Demodicidæ (the Follicle Mites).—Small, elongated mites; anterior region undivided, in adult with rostrum and four pairs of short legs; the posterior transversely striated, without appendages. Tracheæ, stigmata, and eyes wanting. No marked sexual dimorphism. Oviparous. Larva without legs or with three pairs of tubercles, nymph with four pairs of rudimentary legs. Parasites of hair follicles and sebaceous glands of mammalia. Only a single genus with several species.

Demodex folliculorum (G. Simon). = *D. foll.* var. *hominis* auct.; *Steatozoon foll.* E. Wilson. Rostrum short, anterior region of body approximately one-third of total length. Egg cordiform. Male 0.3 mm. long, 0.4 mm. broad; female 0.38 mm. by 0.045 mm.

This form, which presents a characteristic appearance (Fig. 246), is a common parasite of the sebaceous glands of the human skin. It is easily discovered in the sebum from the glands of the nose, lips, and forehead; also in the ceruminous and Meibomian glands, and from the abdominal and pubic regions. Normally the mites rest in the gland, head inward (Fig. 247), and but a few are present in each gland; occasional increase in numbers is said to give rise to stoppage of the duct and from five to twenty may be found in a comedo plug. The statements of some authors, according to which these parasites occur in two-thirds of the persons examined, are held by other investigators to be far beyond the usual percentage of infection. Precise data are lacking. Henle, who discovered this species in 1841, obtained living specimens of the mite from a cadaver six days after death. In spite of the fact that this species is difficult to distinguish from related forms of the dog, cat, and other domestic animals, with a single doubtful exception, no case of infection transmitted in either direction is on record, and all efforts to accomplish this experimentally have failed.

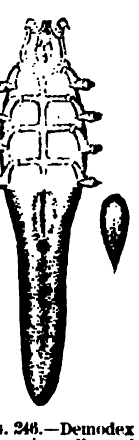


FIG. 246.—Demodex canis. Ventral view of female and of egg. × 100 diameters. (After Mégnin.)

Although *D. canis* gives rise in the dog to a serious dermal disease (Fig. 247) which is rather difficult to handle, no similar difficulty is reported for man with *D. folliculorum*, even in the case of those individuals habitually regardless of personal cleanliness; and an etiological relation between these mites and acne, as maintained by various observers, has not been satisfactorily demonstrated.

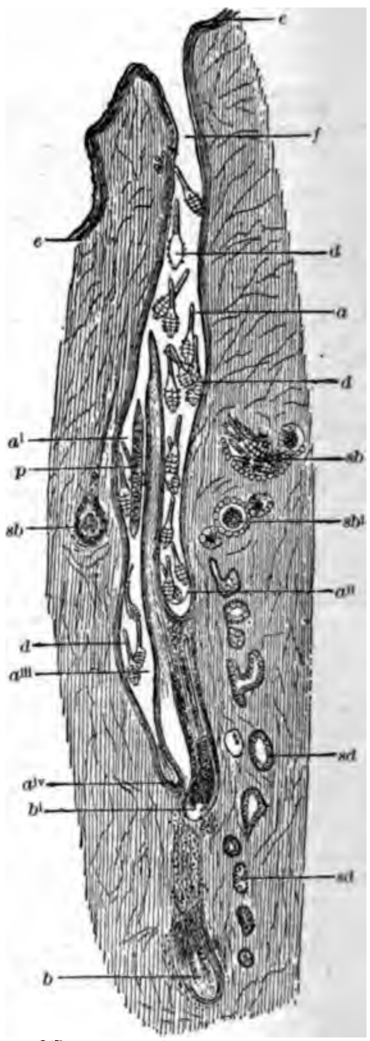


FIG. 247.—Transsection of Skin of Dog, Showing Demodex canis in Position in Hair Follicle and also in Sebaceous Gland. (After Laulanié, from Neumann.) *e*, Epidermis; *f*, hair follicle containing two hairs, *p*, the bulbs of which can be distinguished at *b* and *b*¹; at the points, *a*, a^{I}, a^{II}, a^{III} and a^{IV}, the follicle has undergone dilatation, by reason of the accumulation of the follicle mites, *d*; *sb*, sebaceous glands, one of which (*sb*¹) contains the mites; *sd*, sudoriferous glands. × 40 diameters.

Sarcoptidæ.—Small, pale mites, with soft body, not elongated, separated into two regions by a more or less distinct transverse groove. Mandibles chelate, maxillary palpi styliform. Four pairs of five-jointed legs with epimera, in two groups corresponding to the regions of the body, terminal joints (tarsi) with one or two claws, a sucker, or both, or with long bristle. Tracheæ wanting. Sexual dimorphism general. Metamorphosis with hexapod larva and two nymphs, often complicated by the appearance of a hypopial nymph.

Of the seven sub-families only the Sarcoptinæ or itch mites, and the Tyroglyphinæ or cheese mites, are of importance here.

Sarcoptinæ (the Itch Mites).—Parasitic mites with transversely striated integument, with campanulate pedunculate tarsal sucker, often atrophied and replaced by bristles on the third and fourth pairs of legs. Vulva transverse. Found in the skin of mammals and birds, where they produce the various forms of scab and itch.

Sarcoptes (the Itch Mite of Mammals).—Body round or slightly oval. Rostrum short, and thick; posterior feet entirely or nearly hidden by the body. Tarsal suckers with long, simple peduncle; in female on the first and second pairs of legs, in the male also on the fourth pair. Anus terminal.

Some authors distinguish but a single species with numerous varieties; it seems better, however, in spite of the often insignificant and in part inconstant specific differences thus far known, to follow the later authorities in regarding these forms as different species, even though physiological characters must still be used in part for

margin of the body. The male is much smaller than the female and has the fourth pair of legs terminated by a sucker instead of the bristle which is on the fourth pair in the female. There is also on the ventral surface of the male a complicated chitinous framework wanting in the female.

The human itch mite lives in the skin in which the female tunnels an irregular winding passage, where she passes her entire existence (Fig. 250). These burrows vary in length from a few millimetres to two or more centimetres and are excavated preferably where the skin is thin, as between the fingers, in elbow or knee joint, on mammæ or penis. The gallery, directed first downward through the stratum corneum, is extended through the softer cells of the Malpighian layer just above the papillæ. Eggs and fecal matter fill the most of this tunnel, at the inner end of which may be found the female. The male is much rarer; its existence is passed on the surface of the skin, hiding under scales and in furrows. After an incubation of only a few days there emerges from the egg a hexapod larva, which bores through the roof of the tunnel and gains the surface of the skin, where after three or four moults and the acquirement of a fourth pair of legs the development of

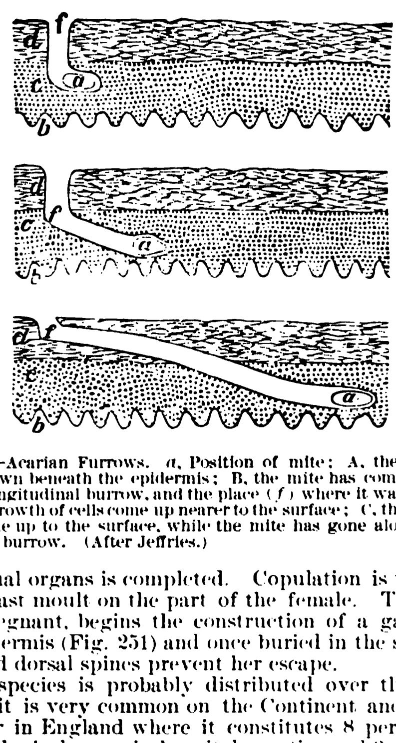


FIG. 251.—Acarian Furrows. *a*, Position of mite; A, the mite has gone down beneath the epidermis; B, the mite has commenced to dig a longitudinal burrow, and the place (*f*) where it was in A, has by the growth of cells come up nearer to the surface; C, the point (*f*) has come up to the surface, while the mite has gone along farther with its burrow. (After Jeffries.)

the sexual organs is completed. Copulation is followed by the last moult on the part of the female. The latter now pregnant, begins the construction of a gallery in the epidermis (Fig. 251) and once buried in the skin, the recurved dorsal spines prevent her escape.

This species is probably distributed over the entire world; it is very common on the Continent and among the poor in England where it constitutes 8 per cent. of dermatological cases in hospital practice and 3 per cent. in private practice. It is much rarer in the United States and is most frequent in the East; in New York Bulkley had 2 per cent. in the hospital and one-fourth of one per cent. in private practice. In Boston White noted an increase from 9 cases in 1880 to 165 in 1888. Of 318,500 cases recorded by the United States Dermatological Association within a period of a little over twenty-one years (from July, 1877, to January, 1898), it was found in 3.66 per cent. of the total number. Although rare under ordinary circumstances, it increases rapidly under conditions of crowding; thus in 1893, the year of the Chicago Exposition, 901 cases were reported in the United States, while in 1895 the total was only 383 cases. Where such crowding is combined with faulty sanitary conditions, it becomes epidemic in a severe form. Thus during the Civil War, the "army itch," "Jackson's itch," and "seven years' itch," which are merely aggravated forms of the disease, followed the movements of the troops.

The disease is produced by the transfer of the parasite by actual contact from an infected person to one not infected. Such infection must transport both sexes, or at least pregnant females, and under such conditions that they can successfully form burrows. In spite of the fact that in large continental hospitals and clinics, yearly thousands of cases are treated and handled by nurses and students without any precautions whatever in the way of disinfection, no trouble is experienced from the disease.

Infection is easily and most commonly brought about by long-continued and intimate contact, and the nocturnal habits assigned by some to these mites are due to their increased activity under the influence of the warmth of the bed. The disease is also most common among men and of such classes and occupations as are wont to sleep together. A transient infection may be induced by the transfer of this species to the horse, dog, or ape, but the cat is apparently immune toward it.

The itch mite excites at first only a moderate irritation, which gradually grows in intensity and becomes an extensive pruritus, accompanied by eczematic inflammation with the formation of papules and vesicles. The malady increases in severity with duration, and especially as the result of scratching, until it may acquire the character of a severe eczema, the vesicles and pustules being associated with extreme excoriations and the formation of crusts. The itch may be confused with eczema and pediculosis, which latter may in fact coexist with it.

The first step in the treatment of the itch is the absolute destruction of the entire colony of mites and their eggs, for which purpose various sulphur ointments are successfully employed. Naphthol is also highly recommended. In severe cases some eczema remains to be treated after the destruction of the mites.

It is important to record here from Nuttall the view of Joly that the itch mites may serve at times as carriers of lepra bacilli. In parts of Norway where much leprosy exists, these mites are also abundant, and, together with pediculi, they are usually found among the poorer classes in Algeria, from which the greatest number of lepers come. "In the Soudan the sarcoptes occur on almost all the dogs [most probably not the *S. scabiei*—W.], and often attack the natives amongst whom there are numerous lepers. It seems to me that the possibility of this mode of transfer cannot be denied, and it is also conceivable that the pathological changes produced in the skin by the parasites may even favor the multiplication of the lepra bacilli."

Sarcoptes scabiei crustosæ (Fürstb.) (Norway Itch Mites). —*S. scabiei* var. *lupi* Mégnin. Dorsal scales obtuse. Anterior projections of epiandrium well developed, reaching the epimeres. Posterior spines long, pointed, easily bent. Male 0.17 by 0.15 mm.; female 0.41 by 0.34 mm.

This form, though much like the preceding, produces such radically dissimilar effects on the human skin that we are forced to regard it as a distinct species. It was first discovered in Christiania, whence the name Norway itch, by which it is commonly known, though cases have been reported in most European nations and one from this country (Indianapolis) by Hessler.

The malady is easily distinguished from the common itch by the formation of coarse crusts, which, however, do not usually make their appearance for some years. This gives color to the view that this form of the itch finds its explanation in individual differences on the part of the host rather than of the parasite. Opposed to this view is the formation of crusts several millimetres in thickness and several centimetres in extent, the enormous numbers of mites found in the midst of these masses and the attacks of the mites on face and scalp where the common itch mite does not occur. This species is apparently transmitted with great ease, and its attacks do not readily yield to treatment. Mégnin's idea that it i identical with the sarcoptes of the wolf is entirely un tenable.

The case reported by Hessler apparently belongs here though the author did not differentiate the parasit

found from the ordinary itch mite. The patient was partially paralyzed and entirely helpless—hence we may infer absence of the ordinary scratching; its sequelæ are apparently entirely wanting. The body of the patient was literally covered with thick, yellowish-white, leathery scales, the largest measuring 25 mm. in diameter and nearly 3 mm. thick; these scales consisted merely of proliferated epithelial cells, and bloody or serous crusts were not present. They were, however, produced by moderate friction. In the scales on the body the author estimates the number of egg cases and eggs as seven million of which one-half to three-fourths were empty, and the number of mites as two million of which only a small fraction were living.

The following forms, normally parasitic on other hosts, may be transmitted accidentally or experimentally to man and give rise to an itch, rarely severe and usually transitory. No doubt other forms yet undescribed will fall in this same category. Besides man, only the most common host is given for each species.

S. aucheniæ. Male 0.24 by 0.18 mm.; female 0.34 by 0.26 mm. On the llama; transmitted to attendants, requiring treatment to dislodge.

S. canis. Male 0.19 to 0.23 by 0.16 to 0.18 mm.; female 0.3 to 0.45 by 0.23 to 0.35 mm. On the dog; frequently transmitted to man, variable in severity.

S. capræ. Male 0.243 by 0.188 mm.; female, 0.345 by 0.342 mm. On the goat; readily transmitted to man; induces an itch of great severity.

S. dromedarii. Male 0.29 by 0.18 mm.; female, 0.36 by 0.33 mm. On the camel; readily transmissible and severe; in Egypt almost all camel drivers are affected; the Senegal negroes call the complaint larbisch.

S. equi. Male 0.22 to 0.28 by 0.15 to 0.2 mm.; female 0.45 to 0.5 by 0.31 to 0.37 mm. On the horse; rare on man, transitory and usually disappears spontaneously.

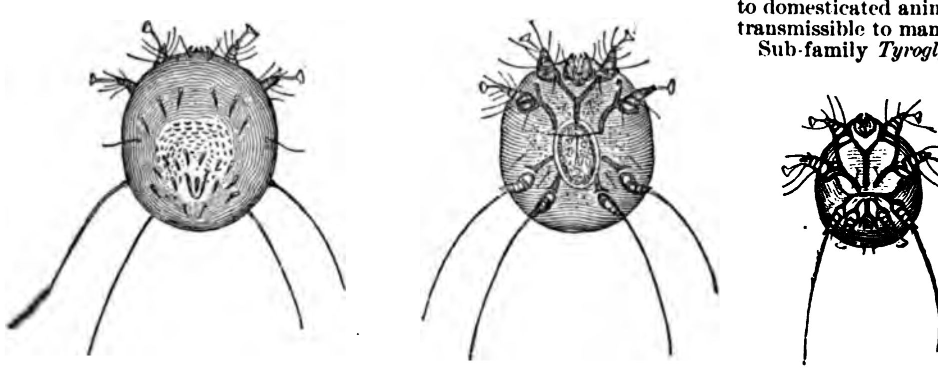
S. leonis. Male 0.25 by 0.18 mm.; female, 0.45 by 0.35 mm. On the lion; easily transmitted to man; disappears spontaneously in thirty to forty days.

S. ovis. Male 0.22 by 0.16 mm.; female, 0.314 by 0.3 mm. On the sheep; very rarely transmitted to man, if indeed at all.

S. suis. Male 0.25 to 0.35 by 0.19 to 0.3 mm.; female 0.35 to 0.5 by 0.29 to 0.39 mm. On the pig; transmitted to man, sometimes disappears, sometimes grows worse.

S. vulpis. Male 0.245 by 0.185 mm.; female 0.442 by 0.315 mm. On the fox; its transmission to man rests on doubtful evidence.

S. wombati. Species not described in detail; forms a crustaceous itch on the wombat; readily transmitted to man; produces a type of itch intense and unlike the ordinary form; yields readily to treatment.



A. B. C.
FIG. 252.—Notoedres cati: A, Female, from Above, B, from Below; C, Male. × 100. (After Railliet.)

Notoedres cati (Hering. = *Sarcoptes minor* Fürstb. Tarsal suckers with long, unjointed pedicle; in the female on the first and second pairs of legs, in the male also on the fourth. Anus dorsal, near posterior margin of abdomen. Dorsal scales obtuse. Male (Fig. 252, C) 0.14 to 0.15 by 0.12 to 0.125 mm.; female (Fig. 252, A, B) 0.21 to 0.23 by 0.16 to 0.175 mm.

This, the itch mite of the cat, attacks on its normal host the skin of the head and ears, and induces a serious, often highly epizoötic malady with a termination usually fatal. This species is of importance here because of its easy transmission to man. On the latter it produces a limited itch which disappears spontaneously at the end of from ten to twenty days. It occurs on cats in Lincoln, Nebr., and doubtless elsewhere; no cases of transmitted infection are, however, on record here.

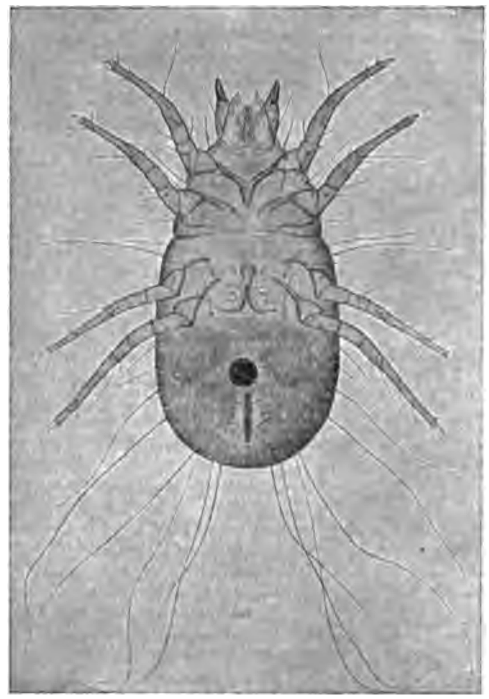


FIG. 253.—Tyroglyphus longior, Female, in Ventral Aspect. (After Mégnin.) Magnified.

The other genera and species of itch mites common to domesticated animals are not known to be transmissible to man.

Sub-family *Tyroglyphinæ* (Cheese Mites).—Minute forms with soft body, without eyes or tracheæ. Integument never uniformly striated, but smooth and granulated or irregularly verrucose. Last leg with claw and usually also with foliate, non-pedunculate vesicle.

These mites (Fig. 253) live in dry or slowly decaying materials (flour, sugar, cheese, anatomical preparations, etc.). From their minute size and abundant occurrence they are liable to be introduced on to or even into the human body, and may even make the passage of the alimentary canal without being entirely destroyed. From their presence on the body or in fecal matter under circumstances of disease they have been often reported as *corpora delicta.* In rare instances certain species

have been transitory parasites of man. Where abundant, as in old groceries or warehouses, they have been known to give rise to a temporary, though often violent dermal irritation on employees handling the infected products, without the evil having been traced in all cases to any single species. Such a complaint is the "grocers' itch" of England. Since these are the most frequent pseudo-parasites with which the physician has to deal, extreme caution should be exercised in associating etiologically any species which belongs in this group with a case of disease in which it has been discovered.

Aleurobius farinæ (De Geer). (The Flour Mite) = *Tyroglyphus farinæ* Gervais. First pair of legs in male much heavier with spur on second joint. White, tip of legs pale violet. Length: male 0.33 mm., female 0.55 mm. Cosmopolitan on flour, fruit, tobacco, cheese, and other organic material in process of alteration by age. This species is much more abundant than the following even in cheese, and has frequently been described as that species in spite of evident differences. It was observed by Moniez as the cause of a cutaneous eruption on workmen unloading Russian wheat at Lille.

Tyroglyphus siro (L.) (The Cheese Mite) = *Acarus siro*, *A. lactis*, *A. dysenteriæ* L. Last pair of legs with both claw and sucker, with terminal joint short and with proximal sucker close to proximal end of terminal joint. Length 0.6 mm. Found on decomposing substances like the last, but rarer. This is the cheese mite reported by various authors from dysenteric stools and from urine. Its occurrence was undoubtedly accidental, and its harmless nature may be adjudged from the quantity taken daily in cheese everywhere and the absence in medical works of any records of consequent diseases. Yet Zürn records that in certain districts where mites are raised to impart a peculiar flavor to the cheese, a gastric or intestinal catarrh is prevalent among consumers of the cheese which he attributes to the effect of the mites. As this species is abundant in old linseed meal, its reported occurrence in poulticed wounds is easily explained. In cantharides it is also abundant, and in vanilla, where its presence has been associated with the vanilla complaint, a dermal eruption frequent among workers handling this product. The famous *Acarus dysenteriæ* of Linnæus, which was found abundantly in stools of one of his scholars and traced back to the wooden vessel from which the young man drank, was probably this species. It has, however, been reported but once since then from dysenteric stools, those of infants in Prague, and the etiological relation may certainly be called in question.

Tyroglyphus longior (Fig. 253), which is similar in habit to the last species, though less abundant, is easily distinguished by its larger size and more rapid movement. It enjoyed transient fame in 1837 as having been produced (!) by the electrical experiments of Cross on weak chemical solutions.

The mummification of bodies in caves has been shown by recent investigations of Mégnin to be due, in some cases at least, not to chemical or atmospheric influences, but to the work of *Tyroglyphus infestans*, which is abundant in such localities. The external appearance of the body and organs of the mummy was well preserved, but microscopical examination showed the tissue to be filled with incalculable myriads of the mite in all stages of development.

Gamasidæ (Beetle Mites).—Skin leathery, reinforced by chitinous plates; mandibles chelate, maxillæ filiform; six-jointed legs terminated by two somewhat concealed hooks. Stigmata lateral, between legs of second and fourth pair, with peritreme directed anteriad. Without eyes.

The Gamasidæ are abundant small mites, often free or semi-parasitic, in the latter case found on insects especially. Certain species occur on the fowl, but are often very troublesome to man. Of the large number of forms which belong in the family only two need especial mention here.

Dermanyssus gallinæ (de Geer) (The Poultry Mite). Body pyriform, slightly flattened; in the male 0.6 by 0.32 mm., in the female 0.7 to 0.75 by 0.4 mm. Color varies from white to dark red according to the contents of the alimentary canal. Legs stout, rather short. Peritreme extends as far as the base of the second pair of legs.

These mites (Fig. 254) swarm in the crevices of poultry houses and in the refuse of the floor, even living in the dung. At night they emerge from their hiding-places and suck the blood of the birds. Under circumstances they increase to such an extent as to become a veritable pest, even to man himself. Many cases are on record in which both children and adults have been subject to repeated attacks of the mites, which give rise to an itching eruption of the skin. Naturally such instances are observed among persons having to handle fowl or to resort frequently to ill-kept poultry houses. Küchenmeister, Railliet, and others record details of cases on the Continent; I have found none for this country.

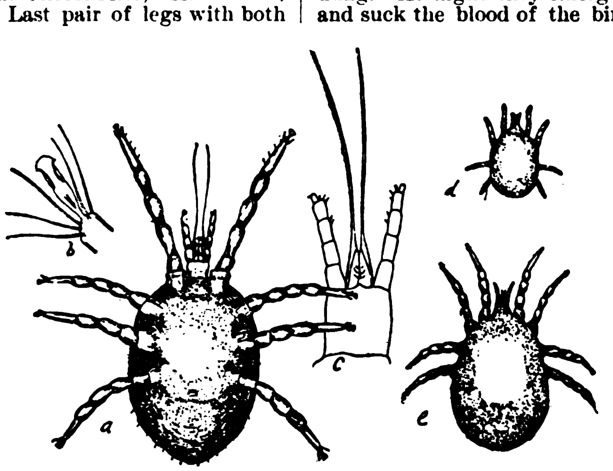


Fig. 254.—Dermanyssus gallinæ. *a*, Adult; *b*, tarsus; *c*, mouth parts; *d*, *e*, young. Magnified. (After Osborn.)

Dermanyssus hirundinis (Hermann) (The Swallow Mite). Decidedly larger than the preceding, reaching a length of 1 mm. Peritreme extends barely to the third pair of legs.

This species, which normally attacks the swallow, has been known to pass from the nests under the eaves into sleeping-rooms and to attack the occupants of the room, giving rise to severe itching.

Trombidiidæ (The Harvest Mites). Soft-skinned, velvety, often highly colored mites, with tracheæ opening at the base of the rostrum or on the cephalothorax, and usually with eyes. Sucking rostrum with styliform mandibles and uncinate palpi. Legs six-jointed, terminated by a double hook together with a small sucker.

Of the large number of terrestrial mites included in this family only a few species are parasitic, but some of these, though only occasionally attacking man, are yet among his most disagreeable chance parasites. Doubtless many other species than these noted here may be found to attack him in one place or another; it is desirable that accurate data regarding all such species be on record. According to Joly and others, these mites are the passive carriers of infectious agents, but Nuttall doubts this and thinks the cutaneous affections produced by their presence on the skin are due to irritating secretions of the mites. The effect Mégnin produced by binding on the skin the dead bodies of one of the most toxic species tends to support this view. To secondary bacterial infection brought about by scratching the skin and to reduced vitality of the latter referable to the mites, are to be attributed the extreme effects manifested

the host, and at best a portion of the skin comes away with the tick.

A drop of turpentine, benzin, petroleum, or even melted butter or oil placed on the head of the tick will often succeed in causing it to loosen its hold and fall from the host. Or it may be torn or cut away, in which case the rostrum is left in the skin to be set free shortly

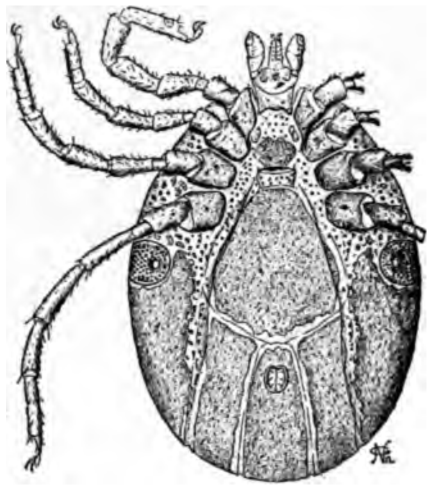


FIG. 257.—Ixodes hexagonus, Male, in Ventral Aspect. × 13. (After Neumann.)

by suppuration. It is worth mentioning that dipping is now extensively practised to free cattle from the ticks which are the means of infection in Texas fever, though the method is still in the experimental stage.

The species which have been found upon man have not been reported with desirable accuracy. Among woodchoppers and others of similar habits, I am informed that the presence of ticks is by no means a rarity, though it rarely becomes a matter of medical record since the animal falls off or is removed by simple means in a brief time without noticeable sequelæ. In a few cases, however, dangerous symptoms manifest themselves, demanding the attention of the physician. These complications may well be due, as Railliet suggests, to the inoculation of infectious agents. Thus he says that Guadeloupe ticks carry "a sort of glanders," due to a specific microorganism, and Blanchard believes that the bacilli of anthrax and tetanus may be also transported in this way. Nuttall, however, regards the evidence as unsatisfactory.

The two sub-families Ixodinæ and Argasinæ may be distinguished easily by the position of the rostrum, which is terminal in the former and, at least in the adult, below the anterior margin of the body in the latter.

Ixodes reduvius (L.) (The Castor Bean Tick)=*I. ricinus* L. Male: brown oval, larger posteriorly, 2.5 mm. long by 1.5 mm. broad. Female: 4 mm. long and 3 mm. broad, or when gorged 10 to 11 mm. long by 6 to 7 mm. broad, ashen gray tending to brown or yellow.

The marked sexual dimorphism manifested by this species was the reason that the male and female were originally described as different species. It is common in Europe and throughout the southern United States from Maryland to Kansas and California. As host it apparently prefers sheep, goat, or beef, less often horse, dog, cat, and even man. Numerous cases of septicæmia apparently resulting from the bite of this species are recorded by European authors. In Norway emphasis is laid on the importance of not tearing off the head of a tick that has begun to bore itself into the skin. This is undoubtedly a wise precaution, and the tick may be removed without damage to the skin by the use of butter, oil, gasolene, or turpentine as mentioned above.

Ixodes hexagonus Leach (The European Dog Tick). In color, form, and size much like the preceding, this form may be distinguished by the shorter rostrum (Fig. 257) and by the tarsi which are also shorter and inflated toward the end. The male (Fig. 257) of this species is also larger, measuring 3.5 to 4 mm. by 2 to 2.5 mm.

This, the common dog tick of Europe, occurs over the entire region east of the Rocky Mountains, where it is reported from a large number of hosts. Blanchard cites cases in which it has even penetrated below the human skin.

The presence of eyes distinguishes sufficiently the genus *Amblyomma*, which includes a large number of species, from *Ixodes*, as the absence of adanal plates separates the former from *Hyalomma*, a genus not yet reported in this country; to this genus belongs the African or Senegal tick, common in tropical regions, especially of Africa, and introduced on cattle into subtropical lands adjacent thereto, where it has been frequently reported on man as the cause of intense fevers; probably the tick was only the agency in transporting the infection.

FIG. 258.—Amblyomma americanum Koch. Adult female. (Original.)

Amblyomma americanum Koch (The Lone Star Tick)=*Ixodes unipunctata* Packard. Male: body brownish red, oval, much elongated posteriorly, 3 mm. long, 2.5 mm. broad. Female (young) colored like the male with a white spot on the back of the living animal. Length 4.5 mm., breadth 3 mm., increasing in gravid females to 8 by 12 mm. (Fig. 258).

This characteristic American species occurs from Labrador to Florida and Texas and is known from South America as well. It is common on cattle in the southern part of the United States, and is reported from other domesticated as well as wild species. Packard reports a case in which a specimen had penetrated into the arm of a young girl, forming there a tumor. It is said to be very annoying to man in the warmer portions of the country, and a correspondent in Texas writes that he removed several females from his own children in one evening.

Dermacentor americanus (L.) (The American Dog Tick) =*Ixodes americanus* Gervais, *I. naponensis* and *I. albipictus* Packard. The body and margins of the legs are marked by silver-white lines and blotches. When gorged, the female measures as much as 14 mm. in length by 9 mm. in breadth.

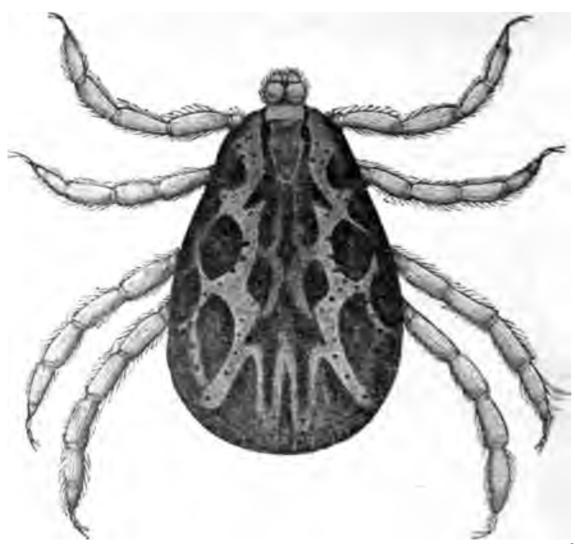


FIG. 259.—Dermacentor americanus, Dorsal view of male. × 10. (After Osborn.)

This most common dog tick (Fig. 259) is reported from almost every State in the Union as well as from Labrador,

ARALIACEÆ.—(*The Ivy Family.*) A family of some forty genera and about four hundred species, widely distributed through temperate and tropical regions of both the old and the new worlds. Its plants are highly ornamental, some, like the ivy, being extensively cultivated for this purpose. Medicinally, it is of note as yielding the famous ginsing. Its constituents are simply aromatic and without special properties. The spikenard, and several other species of aralia, were formerly very extensively used, and are still used to a considerable extent, for these properties. Some of them contain amaroids in connection with their resins and volatile oils.

H. H. Rusby.

ARBOR VITÆ.—(*Thuja* The fresh tops of *Thuja occidentalis* L., Fam. *Coniferæ.*) This is a North American tree, growing abundantly in Canada and the Northern States, and extending at higher elevations as far south as Pennsylvania and Virginia It is a middling or good sized evergreen tree with spreading and graceful branches, and a fine, often large, trunk, which supplies a close-grained, durable wood. It is occasionally planted here for ornament, but more often abroad, where it is valued as a garden tree; the *Arbor vitæ* of our gardens is usually the smaller, closer, erect-branching *Thuja orientalis* Linn. of Asia, which is a favorite hedge plant The genus to which these belong is a small one of only a dozen species.

The twigs were thus described in the Pharmacopœia, edition of 1880: "Twigs flattish, two-edged, the scale like leaves appressed and closely imbricate in four rows, rhombic-ovate, obtusely pointed, with a roundish gland upon the back; of a balsamic, somewhat terebinthinate odor, and a pungently aromatic, camphoraceous, and bitter taste."

Arbor vitæ contains about one per cent. of a *volatile oil*, something like that of juniper; *tannic acid* (pinitannic); a minute amount of a glucoside called *thujin*, etc.

Medical Properties.—Astringent, diuretic, expectorant, tonic, etc., in no direction of much value. Sometimes used for cough; a tincture is employed occasionally for external use upon ulcers, rheumatic joints, etc. Dose, 2 to 4 gm. An alcoholic fluid extract would be a suitable preparation.

W. P. Bolles.

ARCACHON.—The town of Arcachon lies about thirty miles southwest of Bordeaux, on the margin of a very extensive salt-water lake, and some ten miles back from the Atlantic coast. The modern origin of the town is indicated by the motto inscribed upon its coat-of-arms, *Heri solitudo, hodie pagus, cras civitas;* which motto is also an indication of the former character of the surrounding country. A desert waste of barren sand dunes extended for many miles in every direction about the present site of Arcachon, until the French Government, some fifty years ago, conceived the project of planting these dunes with pine forests, as a means of immobilizing the sand which, driven by the fury of the Atlantic gales, was continually encroaching more and more upon the country of the interior. A thick forest of these trees (Pinus maritima) now covers the whole face of the country, and by these pine-covered sand hills the site selected (in 1854) for the now well-known sea-coast resort of Arcachon is shut in and protected on every side except upon the north, which is occupied by the great salt-water lake above mentioned, upon whose southern shore the town is built.

[There are nine thousand acres of these pine trees, which produce a most peculiar stillness—owing to the deep sand roads and walks not giving any sound, and the pine trees having no leaves to rustle.—*E. O. O.*]

From its close proximity to the Atlantic Ocean, Arcachon necessarily possesses a climate characterized by the moderate moisture of atmosphere, and by the equability of temperature proper to most maritime stations. The direction of the prevailing winds, which in this region blow from the ocean, is an important factor insuring to this sea-coast station its proper maritime climate. From the direct violence of the Atlantic gales, as well as from the winds blowing from the east and south, Arcachon is sheltered by the dense pine forest which clothes the surrounding sand dunes; while the sandy nature of its soil serves in some measure to diminish the tendency to excessive atmospheric humidity which might, perhaps, be expected to exist in a region thus exposed to ocean winds.

Winds blowing from the north and from the northeast reach Arcachon after passing over its great lake or land-locked bay, the circumference of which is stated by Dr. J. H. Bennet to be sixty-eight miles in length. Such north and northeast winds, therefore, "become somewhat warmed in winter, and their irritating dryness diminished, while it is maintained that they also bring from the surface of this unusually salt sea water, and from the vast extent of sands exposed by the retreating tides, an appreciable amount of saline and other marine emanations, to give a special efficacy to the air in certain scrofulous conditions" ("Health Resorts and Their Uses," by J. Burney Yeo, M.D., p. 261). According to the author just quoted, the prevailing winds at Arcachon, namely, the sea winds blowing from the northwest, west, and southwest, occur most frequently from December to February, "usually blow continuously day and night for several days in succession . . . often blow with great violence, and were it not for the protection of the lofty pine-trees . . . would form a serious drawback to the climate." The average number of rainy days in that portion of France in which Arcachon is situated is stated by Lombard to be one hundred and thirty, while the total amount of the annual rainfall is twenty-three inches, a greater part of which falls during the winter and autumn months than during the spring and summer seasons

The mean temperature for the year at Arcachon is 59° F.; the mean temperature of the winter season 46.4° F. to 50° F. (Lombard). At Bordeaux the mean winter temperature (according to the same author) is 43.7° F., and the mean annual temperature is 55.6°. A very pronounced difference of temperature between these two points is thus made manifest despite the trifling difference in latitude existing between them. According to data quoted from Dr. G. Hameau in the "Dictionnaire Usuel des Sciences Médicales," the result of a series of thermometric observations taken in the pine woods at Arcachon, and covering a period of ten years, showed the mean annual temperature at 8 A.M. to be 55.76° F., and at noon to be 59.96° F.; for the minimum temperatures the annual mean was found to be 46.94° F.; for the maximum temperatures it was 66.2° F.

Arcachon is both a summer and a winter resort, and there are two distinct portions of the town, the one, adapted for residence during the warmer months, lying directly on the shore of the salt-water lake or basin, and possessing facilities for bathing; the other lying away from the water in the midst of the pine forest, separated from the shore town by a high sand dune, and consisting of "numerous villa residences actually built in the forest, each house being surrounded by pine trees" (Dr. J. Burney Yeo, *op. cit.*). This latter section is known as the Ville d'Hiver, or winter town, while the former is called the Plage, or beach. Of this Plage, Dr. Yeo remarks that it is "occupied by somewhat closely packed streets and houses," and becomes in summer time "a sort of Margate for the population of Bordeaux." Dr. J. H. Bennet says of Arcachon that it is "a pretty sea-side town . . . with good hotels, picturesque villas, convenient and handsome club house and baths—indeed, all the appurtenances of advanced civilization. The summer town is built on the sandy shore of the great lake or sea, which affords excellent bathing. The lake itself, from its great extent and from its being landlocked on every side, offers every possible facility for safe boating, yachting, and fishing." After describing the Ville d'Hiver and giving much other interesting information concerning Arcachon in his entertaining book, "Winter

and Spring on the Shores of the Mediterranean" (fifth edition, 1875), and after alluding to the "rather mild and equable temperature" of the winter climate at Arcachon, to the advantage it possesses over Biarritz in being surrounded by pine forests, affording "considerable shelter against wind for walks and drives," etc., etc., Dr. Bennet nevertheless expresses the opinion that the place has been over-estimated as a winter residence for consumptives, and that it is not so favorable for this class of patients as is the Genoese Riviera. Dr. Sparks, in his article on the treatment of disease by climate, in Quain's "Dictionary," specifies Arcachon as a good resort for neuralgic patients. This place certainly presents to the invalid the rather unusual combination of a mild sea-side resort and of a pine-woods sanitarium. The air of its surrounding forests is said to be remarkably rich in ozone, and is of course laden with the balsamic exhalations always to be found where trees of this species abound. According to Dr. Yeo, the climate of Arcachon is "sedative yet not relaxing," is "mild," and is "especially suitable to cases of irritative bronchial or laryngeal catarrh, to cases of phthisis with tendency to congestion or inflammatory complications, and to persons of nervous temperament. It is not suited to persons of a lymphatic and torpid habit, who do better in the tonic and stimulating air of the Western Riviera. Cases of consumption and of other chronic lung diseases have certainly been arrested at Arcachon, and dyspeptic persons, in whom the dyspepsia has been complicated with hysteria, hypochondriasis, and nervous irritability, have derived great benefit from its climate" (J. Burney Yeo, *op. cit.*, p. 262). *Huntington Richards.*

[Dr. Lalesque, in a work entitled "Cure Marine de la Phthisie Pulmonaire," Paris, 1897, gives a very exhaustive analysis of the climate of Arcachon, and its application in the treatment of pulmonary tuberculosis. He writes as an enthusiast on the efficacy of an Atlantic marine climate associated with the balsamic atmosphere of pines, in the cure of pulmonary tuberculosis. An analysis of 252 cases treated by him at Arcachon gives the following results. Prophylactic action—68 cases with 68 cures; Curative action—184 cases, divided as follows: of the first stage, 79 cases with 27 cures, 40 improved, and 12 aggravated; of the second stage, 45 cases, with 9 cures, 24 improved, and 12 aggravated; of the third stage, 60 cases with four cures, 21 improved, and 35 aggravated. In 184 cases, then, he obtained 21.7 per cent. of cures and 46 per cent. improved. He applies very rigorously the "Cure d'air et de repos," although his patients are not under sanatorium control; and he thinks the "cure marine," as illustrated by Arcachon, gives results comparing favorably with those obtained in the mountain resorts, both being efficacious through a common element, pure air. Undoubtedly constant exposure in pure air is the principal factor in the climatic treatment of pulmonary tuberculosis, whatever the climate and wherever the resort; but so far, the high altitudes have given appreciably better results, as shown by the statistics, especially the recent ones of Turban at Davos. The open-air treatment, however, is still in its infancy, and in its wider and more strenuous application we shall, in the writer's opinion, obtain surprising results in any and all climates.—*E. O. O.*]

ARCO.—This village occupies in Austrian estimation the position which is held in Italy by San Remo, and in France by Mentone. It is situated in the extreme southern portion of the Austrian Tyrol, on the line of the railway between Botzen and Verona, three miles distant from the beautiful Lake Garda. It lies in a valley enclosed, on all sides but the south, by lofty mountains rising from four to seven thousand feet. The northern opening is protected by a mass of rock 370 feet high. The elevation of the village is slight, viz., from 250 to 500 feet above sea level. It is said to be almost windless; but little rain falls and snow is seldom seen. Its climate during the winter, which is the time of residence for invalids, is mild and equable, as the following chart indicates:

OBSERVATIONS OF TEMPERATURE AT ARCO, WINTER, 1875-1876.

(From Eulenburg's "Real-Encyclopädie.")

(Fahrenheit Scale).

Month.	Monthly mean.	Mean maximum (at noon).	Mean minimum (at noon).
October	59.5°	71.9°	52.2°
November	50.2°	60.8°	42.8°
December	41.8°	53.6°	42.8°
January	43. °	61.7°	39.2°
February	45.3°	64.4°	41. °
March	50.4°	66.2°	44.6°
April	59. °	75.2°	50. °

The relative humidity is about 72 per cent.

Dr. Weber (Ziemssen's "Handbuch der allg. Therapie," Bd. ii., S. 173) gives the following facts concerning the climate of the Italian lake region, and includes Arco in his list of places properly belonging within this climatic district. The relative humidity of such points he states as being between 72 and 78 per cent. during the autumn and winter months, and somewhat less than 70 per cent. in the spring season. The average number of rainy days is from 36 to 40 during the autumn, from 34 to 36 during the spring, and from 15 to 20 during the winter. Snow falls, as a rule, in this region, on not more than 6 or 8 days of the year, and seldom lies for several days together upon the ground. Among the local winds which prevail about all great lakes, those blowing from the north and from the northeast are of most frequent occurrence in this region. Fogs are rare; there are few days during which an invalid must keep within doors from sunrise to sunset; and there is less dust than is found along the Italian Riviera.

The mildness of the climate is shown by the fact that the orange ripens in the open air, and the olive tree, the fig, and the pomegranate also flourish.

The invalid's day is nine hours long in October, seven in November, six in December, five in January, six in February, eight in March, and the whole time between sunrise and sunset in April. The season extends from September 1st to April 1st. The class of diseases for which Arco is suited as a residence are affections of the chest and throat, anæmia, want of appetite, nervousness, chronic catarrh of the stomach, intermittent fever, rheumatism, gout, and the scrofulous affections of children. There are provisions for the various forms of hydropathic treatment, and an Oertel Terrain-Cur.

The drinking-water is of good quality, and the accommodations are said to be comfortable and easily obtained. There are many attractive walks and pleasant excursions in the neighborhood.

Weber classes Arco as among the lowest Alpine climates and says its winter climate is "sufficiently mild for persons with stationary phthisis, or convalescents from the same disease, and also for those whose object is only to find change and a sunny climate."

All cases of pulmonary disease suitable for the medium and higher altitudes would of course be suitable for this climate, which offers favorable conditions for the open-air treatment; and, after all, this is the principal factor in any climatic treatment of pulmonary tuberculosis.

For the above account of Arco the writer is indebted to Dr. Huntington Richards' report in the previous issue of the HANDBOOK, and to Roe's "Health Resorts and the Bitter Waters of Hungary." *Edward O. Otis.*

ARCTIC SPRINGS.—Trempeleau County, Wisconsin. POST-OFFICE, Galesville. Hotels in Galesville.

These springs are situated near the village of Galesville, at the terminus of a branch of the Chicago and Northwestern Railroad. The springs are at the head of a small lake called "Marinuka," while the village is at the foot, about a mile away. During the summer a small steamer carry-

ing fifty passengers plies between the two points. The location is seven hundred and fifty feet above the sea level. The country surrounding the springs is broken by ranges of elevations called "bluffs," between which are beautiful and productive valleys from one to three miles wide. The main valleys are intersected by smaller depressions at intervals of about a mile. All of these valleys contain clear trout streams coursing down their centres. This peculiar conformation gives the country an aspect of picturesque beauty not soon forgotten when once seen. The fine scenery and salubrious climate are beginning to attract visitors to this region in rapidly increasing numbers. A large hotel is badly needed. The springs flow from beneath a precipitous bluff out of the rocks, filling a pipe six inches in diameter. The water as it flows has a temperature of 48° F. The following analysis was made by Prof. W. W. Daniels, of the State University:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium sulphate	0.19
Sodium sulphate	0.07
Sodium chloride	0.76
Calcium chloride	0.05
Calcium bicarbonate	13.65
Magnesium bicarbonate	9.84
Iron bicarbonate	0.26
Alumina	0.15
Silica	0.06
Total	25.03

The water is a mild alkaline-calcic, with light chalybeate properties. It is useful in acid dyspepsia, chronic constipation, renal congestion, the early stages of Bright's disease, and in general debility.

Galesville is a thrifty village of more than one thousand inhabitants, and numbers among its attractions telegraph and telephone facilities, electric lights, water-works, a fine water-power, etc. *J. K. Crook.*

ARCUS SENILIS.—Gerontoxon (from Greek, γέρων, old man, and τόξον, bow, arch); *Macula arcuata* or *macula corneæ; Marasmus senilis corneæ; Annulus senilis;* German, *Greisenbogen;* French, *Arc Sénile.*

Arcus senilis occupies the peripheral portion of the cornea as a light gray arc. The opacity, smooth on the surface, is more pronounced toward the limbus, being sharply defined from it by a narrow, transparent strip, while the concavity of the arc emerges gradually into the transparent cornea. The opaque arc always appears first above, and gradually advances downward. It always remains broadest above and is at the same time more opaque in this part. Finally, the two arcs unite at the outer and inner side of the cornea to form a closed ring.

The opacity is at first of a light gray color, appearing like a silver band. At a later period, the opacity assumes a denser and more creamy tint, increasing at the same time in depth and width. Arcus senilis, as the name indicates, is an affection of advancing years, and rarely occurs under fifty years of age except in those infrequent cases in which it seems to occur as an inherited characteristic. Thus, for example, I know of a family in which three male members have all had the completed arc as early as at the age of thirty-five, and in none of them is there any apparent cachexia.

The condition is usually bilateral, although one eye alone may be affected. It occurs more frequently and at an earlier date in men than in women. In warm climates it is developed earlier than in cold latitudes, and it is frequently seen in negroes on the north coast of Africa.

A condition resembling very much arcus senilis is found in the young, but is not to be confounded with it. It has been called by Wilde *arcus juvenilis*, and may be distinguished from the former by the presence of a diaphanous ring between the margin of the cornea and the opacity.

Arcus senilis never interferes with vision, although it may extend somewhat into the corneal substance.

PATHOLOGY.—Arcus senilis is due to an infiltration of a finely granular hyaline substance. It is commonly stated, even in the more recent text-books, that it is due to a fatty degeneration or infiltration of the cornea; but this has been shown by Fuchs not to be the case, for he says it is a typical example of physiological, non-inflammatory opacity. He found that the infiltrated material never has any relation to the cells of the corneal tissue, but lies free upon the surface of the connective-tissue fibres. Neither ether nor chloroform has any effect upon it; consequently it cannot be of a fatty character. Fuchs considers it to be a hyaline degeneration of certain fibres.

This deposition of hyaline masses is also associated with deposits of minute particles of lime on the more superficial layers of the cornea, close to the limbus, and the cause is assumed to be a senile atrophy of the limbus, with involution of a portion of the vascular loops contained therein. Gruber attributes the appearance of these changes in this particular portion of the cornea to the peculiarities of the circulation in the cornea; the peripheral zone being nourished mainly by transudation of nutritive materials from the circumcorneal plexus. At the same time the changes in question are favored by the fact that, with advancing age, the circulation grows less active and consequently the nutrition progresses more feebly.

Arcus senilis would, therefore, appear to be a normal phenomenon, that occurs in perfectly healthy people, is due to the decrease of nutrition incident to advancing years, and has no relation to fatty degeneration of the heart, as was formerly supposed.

There are no symptoms. The slight disfigurement and the apprehension of future trouble which many, not knowing its character, anticipate, constitute the only sources of annoyance. So far as the patient's fears are concerned, these may easily be allayed; for the condition never interferes with vision. Incisions through the arcus senilis, as in the extraction of cataract, heal as well as those made through the clear parts of the cornea.

William Oliver Moore.

AREA EMBRYONALIS.—Eggs may be divided into two general classes: holoblastic, which have a complete segmentation; and meroblastic, in which only a portion of the egg becomes divided into cells during the process of cleavage. In the first class the eggs contain little or no yolk, like the egg of a starfish. In the second class, on the other hand, there is a great deal of yolk, as in the hen's egg (see article *Segmentation of the Ovum*).

It is the second class of eggs, as a rule, in which the distinction can be drawn between the strictly embryonic portion, or *area embryonalis*, and the strictly extra-embryonic portion, or yolk sac. The area embryonalis is spoken of also as the *area germinativa, germinal disc,* or *blastoderm*. While as a rule holoblastic eggs do not show a differentiation into these two areas, it is a remarkable fact that the mammalia present a minute egg which undergoes complete segmentation and yet in its subsequent development follows the type of the meroblastic eggs.

The area embryonalis of the hen's egg may be taken as presenting the typical structures. This has been the subject of investigation by a number of authors, the most complete and satisfactory description being that given by Mathias Duval.

At the close of segmentation the area embryonalis, or blastoderm, consists of a lenticular mass of cells, about 2 mm. in diameter, lying in a hollow over the plug of white yolk. The rest of the egg is unsegmented, but in the yolk close to the periphery of the blastoderm are a number of nuclei that may be called the yolk nuclei, or *periblastic* nuclei. The blastoderm consists of two layers: an outer single layer of columnar cells, the ectoderm, and an inner mass of rounded cells, the primitive entoderm. As the blastoderm increases in size the entodermal cells in the centre become more loosely arranged, forming finally a layer one cell deep, which is separated from the yolk by

a *subgerminal cavity* filled with fluid. At the margin, on the other hand, the entoderm forms a thick rim, and at the extreme edge it is impossible to draw an exact boundary line between the entoderm and the ectoderm. At this stage the marginal rim is somewhat broader and

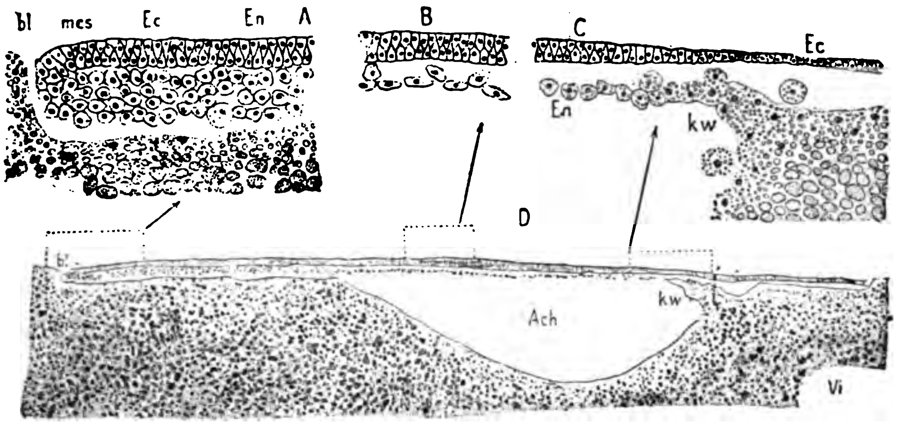


FIG. 261.—Median Longitudinal Section Through Hen's Blastoderm Incubated six hours. D, × about 40 diameters; A, B, C, details of D more highly magnified; *Ach*, subgerminal cavity; *Ec*, ectoderm; *En*, entoderm; *kw*, germinal wall; *mes*, marginal rim. (After Duval, from Minot.)

thicker at the posterior margin than it is at the anterior. Later, the ectoderm becomes separated from the entoderm at the margin and grows over the surface of the yolk. This process, by which the rim gradually disappears, begins at the anterior edge. Between the fifth and eighth hours of incubation it has reached the sides of the blastoderm, and it finally extends around the whole periphery. At the same time the entoderm becomes connected with the yolk at the edge of the subgerminal cavity, which meanwhile has become deeply excavated and bounded at the margin by a perpendicular wall (Fig. 261). Further growth of the entoderm takes place by the addition of cells from the periblast. The periblastic nuclei divide, and those nearest the margin become surrounded by a small body of finely granular protoplasm, and the cells thus formed by cleavage of the yolk are added to the margin of the entoderm.

It is now possible to divide the area embryonalis into two regions. The central transparent portion overlying the subgerminal cavity is called the *area pellucida*, while the peripheral portion in direct contact with the yolk is the *area opaca*.

While the marginal rim is disappearing from the anterior edge of the blastoderm, a new structure is making its appearance on the median line extending from the posterior edge toward the centre of the area pellucida. This is the *primitive streak*. In a surface view it appears as an opaque area, and in sections it is found that the ectoderm and entoderm have the same relations to one another that they do in the marginal rim. That is, there is an accumulation of the primitive entoderm which cannot be separated from the ectoderm by any sharp line of demarcation (Fig. 262, *pr*). The primitive streak elongates with the general enlargement of the blastoderm until the marginal rim is reduced to a mere point of connection between the primitive streak and the edge of the blastoderm—about the twelfth hour of incubation. Finally, the ectoderm separates from the entoderm at this point also and grows out over the yolk. In this way the primitive streak acquires the position shown in Fig. 263.

From his observations Duval concludes that the primitive streak is formed by the concrescence of the marginal rim, as if the enlargement of the blastoderm were arrested at one point and the margin at the two sides of this point were brought together. This is best illustrated by Duval's diagram, Fig. 264.

The growth of the blastoderm of the chick has been studied experimentally by Assheton, Miss Peebles, and Kopsch, but Assheton's experiments are the only ones that bear directly upon Duval's theory. The experiments were made by inserting a fine sable hair in the unincubated blastoderm, after which the egg was placed in the incubator and the position of the hair was noted in the subsequent stages of development. It was assumed that, according to Duval's theory, a hair placed in the posterior median portion of the marginal rim should appear, when the primitive streak is formed, somewhere in front of the primitive streak (Fig. 265, (*i*), *a*), and hairs inserted in the posterior margin at X X should appear in the primitive streak or prevent its formation. On the contrary, it was found that hairs inserted at *a* and X X appeared behind the primitive streak in the area opaca (Fig. 264, *ii*), while a hair inserted at the centre of the unincubated blastoderm appeared at the anterior end of the primitive streak. From these experiments it may be concluded that the primitive streak of the chick does not form by concrescence, but that its anterior end is formed *in situ* by the multiplication of cells in that area, and its further increase in length is probably due to an area of proliferation at its posterior end. These results are in accord with the observations of Morgan on bony fishes and of H. Virchow and Kopsch on sharks. In the blastoderm of Scyllium there is a distinct notch in the line of the primitive streak, and Kopsch found that a wound at the edge of this notch would interfere with the formation of the embryo; but a wound of the marginal rim a short distance from the notch caused only a distortion of the

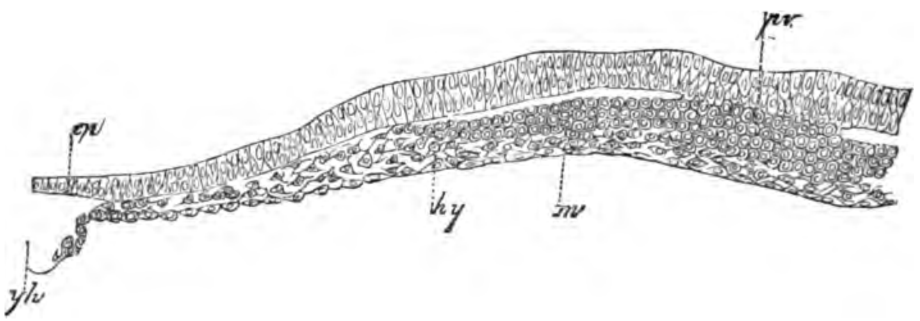


FIG. 262.—Transverse Section through the Front End of the Primitive Streak of the Germinal Area of a Hen's Ovum, incubated about eighteen to twenty hours. (After Foster and Balfour.) *pr*, Primitive streak; *ep*, ectoderm; *hy*, entoderm; *m*, mesoderm; *yh*, germinal wall.

extra-embryonic part of the blastoderm and a curving of the embryo.

During the latter half of the first day of incubation of the hen's egg the definitive entoderm is formed by the

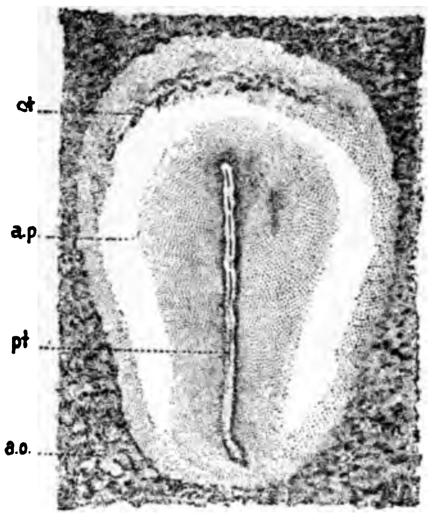


FIG. 263.—Area Pellucida of the Hen's Egg Incubated about 16 hours. *a.o.*, Area opaca; *ct*, anterior crescent; *a.p.*, area pellucida; *pt*, primitive groove beneath which is the primitive streak. × 20. (After Duval, from Minot.)

arrangement of the cells on the lower side of the blastoderm in a continuous single layer of flattened cells. In the region of the primitive streak there is left a mass of cells continuous with the ectoderm above but separated from the entoderm below. These cells form an important part of the mesoderm. According to Duval they are the remains of the primitive entoderm, but according to Marshall they are of ectodermal origin. In the anterior and lateral parts of the area pellucida other mesodermal cells are formed by proliferation of the entoderm.

The mesoderm of the primitive streak extends in all directions, but most rapidly posteriorly where it extends out over the yolk beyond the entoderm. Three stages in the extension of the mesoderm are shown in Fig. 266, where the area covered by the mesoderm is rep-

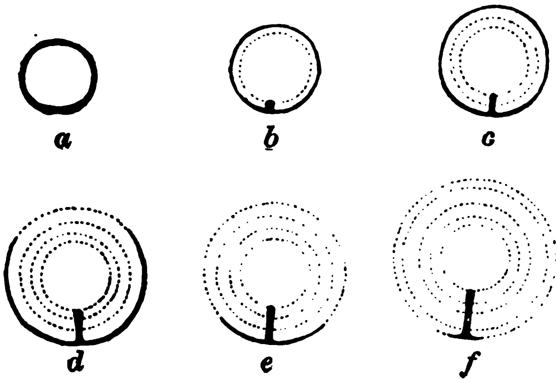
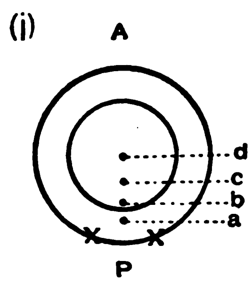


FIG. 264.—Diagrams to Illustrate Duval's Theory of the Formation of the Primitive Streak by the Concrescence of the Marginal Rim. *a*, Marginal rim complete; *b*, first appearance of primitive streak at posterior margin, the dotted circle indicates the relative position of the rim in *a*; *c*, *d*, *e*, succeeding stages; *f*, remnant of rim at posterior end of nearly completed primitive streak. (After Duval.)

resented by the vertical shading. By this time the area pellucida has changed from its original circular form to a pear-shaped outline, and the extra-embryonic ectoderm has spread far out over the yolk, which it will ultimately inclose.

Nothing is known regarding the area embryonalis of man, and owing to the great difficulty of obtaining material it has been studied in but few of the other mammalia. At the close of segmentation of the mammalian ovum the blastoderm is a closed vesicle consisting of a single layer of cells, except in the disc-like area embryonalis where there is an accumulation of cells. In the rabbit, in which the early stages are best known, this area is at first circular. It consists of an outer covering layer, the Deckschicht of Rauber, continuous with the single layer of cells forming the rest of the blastodermic vesicle. Beneath the covering layer is a heap of cells which soon become differentiated into two layers, each one cell thick, the inner ectoderm and the entoderm. Later, the covering layer, or outer ectoderm, disappears as a separate structure by its cells becoming interpolated with those of the inner layer. According to Assheton this circular area forms the primary area of growth of the young embryo. A secondary area of growth appears on the periphery of the primary area at about the one hundred and sixtieth hour after coitus. In this secondary area the primitive streak is formed, from which wings of mesoderm grow out as in the chick. By the end of the eleventh day the area embryonalis of the rabbit has assumed the form represented in Fig. 267.

The embryo is seen lying in the centre of the area and surrounded by a more transparent portion, the area



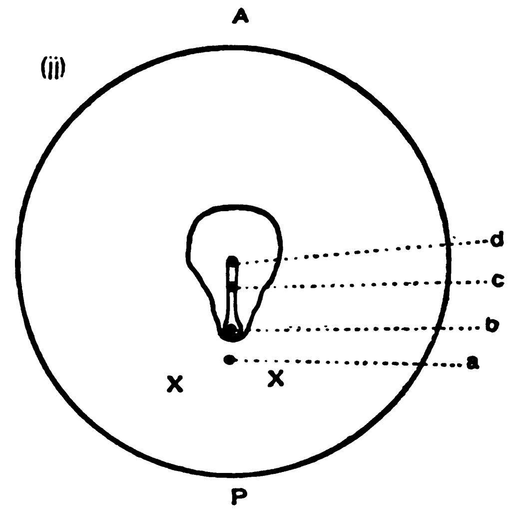


FIG. 265.—Diagrams to Illustrate Assheton's Experiments. (*i*), Unincubated blastoderm of a bird; (*ii*), blastoderm after the complete formation of the primitive streak. (After Assheton.)

amniotica, corresponding approximately to the area pellucida of the chick. Beyond this is the area vasculosa. A part of the ectoderm in this region has already come into intimate contact with the wall of the uterus, forming the area placentalis.

In some rodents, for example the rat, the area embryonalis is formed as a solid plug of cells which grows inward and subsequently acquires a lumen, so that what is morphologically the external surface of the ectoderm becomes the wall of a closed sac. In such cases we have a condition that has been described as an inversion of the germ layers, the entoderm appearing to lie outside of the ectoderm (Fig. 268).

Certain features of the earliest known human embryo have given rise to the supposition that there may be a similar inversion of the germ layers in man.

The origin of the area embryonalis is described under *Segmentation of the Ovum*, and the formation of the em-

bryo is treated in the article on the *Fœtus*. It remains for the present article to discuss only the later changes in the extra-embryonic area.

The most important function of the extra-embryonic area is the formation of blood-vessels and the blood.

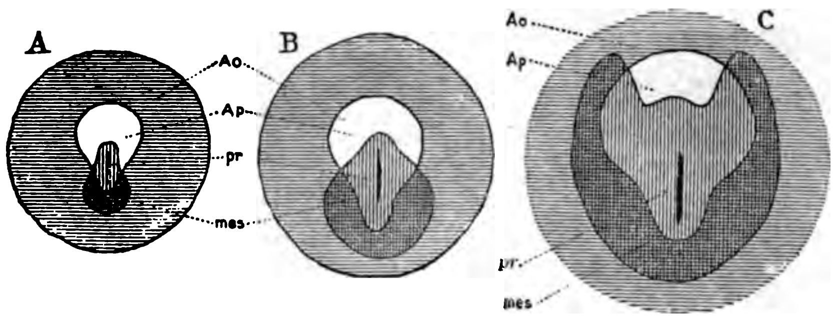


FIG. 266.—Diagrams of the Area Embryonalis of the Chick, Showing Growth of the Mesoderm. *Ao*, Area opaca; *Ap*, area pellucida; *mes*, mesoderm; *pr*, primitive streak. (After Duval, from Minot.)

This begins in the chick in that part of the area opaca where the wings of mesoderm spread over the yolk forming the area vasculosa, and in the rabbit it occurs in the homologous area. From this the vessels extend later through the area pellucida into the embryo.

According to Srahl, in the lizard, on the contrary, the blood and the blood-vessels appear first in the area pellucida.

Toward its edge the area vasculosa is so thick that it appears as though the whole mesoderm took part in the formation of the blood-vessels. But wherever the splitting of the mesoderm into the two layers, somatopleure and splanchnopleure, has taken place it is seen that the blood-vessels form in the inner layer, next to the entoderm, that is, in the splanchnopleure. The formation of blood corpuscles and the development of the vessels are intimately connected. Schäfer's account of the process is as follows:

"Those mesoblastic cells in the vascular area which are concerned with the formation of vessels (*angioblasts*) become extended into processes of varying length, which grow out from the cells in two or more directions. The cells become united with one another, either directly or by the junction of their processes, so that an irregular network of protoplasmic nucleated corpuscles is thus formed. Meanwhile the nuclei become multiplied, and whilst the greater number remain grouped together in the original cell bodies, or nodes of the network, some are seen in the uniting cords. The nuclei which remain in the nodes accumulate, each one around itself, a small amount of cell protoplasm. The corpuscles thus formed acquire a reddish color, and the protoplasmic network in which they lie becomes vacuolated and hollowed out into a system of branched canals enclosing a fluid, in which the nucleated colored corpuscles float (blood islands). The intercommunicating canals gradually become enlarged so as to admit of the passage of the corpuscles. The protoplasm which forms the walls of these first vessels becomes differentiated around the nuclei, which here remain embedded in it, so as to give rise to the flat cells which compose the blood capillaries."

These first-formed blood corpuscles are nucleated in all vertebrates, and the corpuscles remain nucleated throughout life in all except the mammals. In later embryonic life red blood corpuscles are formed in the subcutaneous tissue, in the liver, the spleen, lymph glands, and in the marrow of bones. In the adult under normal conditions new red blood corpuscles are formed only in the red marrow of certain bones, the ribs, sternum, short bones of the extremities, and epiphyses of the long bones.

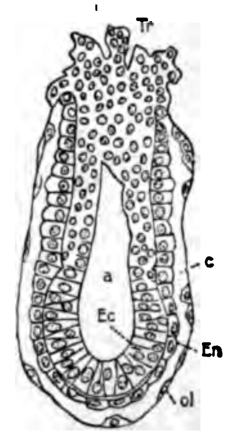


FIG. 268.—Blastodermic Vesicle of a Mouse, Mus Sylvaticus. *a*, Cavity of "Träger"; *Ec*, ectoderm; *En*, entoderm; *c*, cavity of vesicle; *ol*, outer layer; *Tr*, "Träger." (After Selenka, from Minot.)

The study of the development of the blood corpuscles in later embryonic life and in the adult presents many difficulties, and therefore the results obtained by the numerous investigators differ greatly in regard to details. It seems to be fairly well established, however, that the red blood corpuscles are formed by division of primary blood cells, erythroblasts, which have nuclei that divide by mitosis, and in which the cytoplasm contains hæmoglobin. Whether the erythroblasts arise within the capillaries or outside of them, and whether the erythroblasts have an origin in common with the primary white blood corpuscles, leucoblasts, or are cells of a peculiar kind, are questions that have been answered so differently by different investigators that no general rule can be stated. The red blood corpuscles of the mammals, at any rate, are at first nucleated cells. According to some

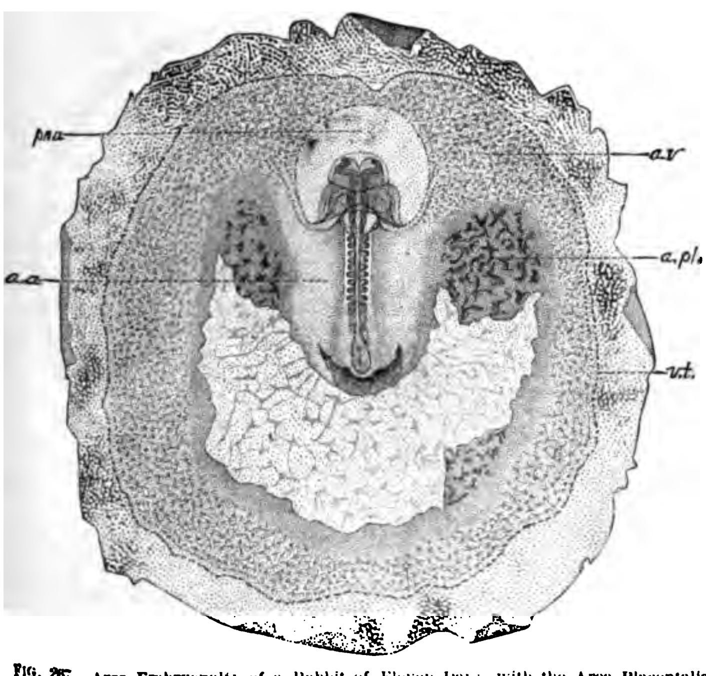


FIG. 267.—Area Embryonalis of a Rabbit of Eleven Days, with the Area Placentalis partly torn off. (After Van Beneden and Julin.) *pr.a.*, Proamnion; *a.a.*, area amniotica; *a.v.*, area vasculosa; *a.pl.*, area placentalis.

accounts the nuclei are extruded from the corpuscle, according to others they undergo degeneration *in situ* and thus disappear.

Schäfer has described as occurring in the newly born rat a peculiar method of origin of red blood corpuscles.

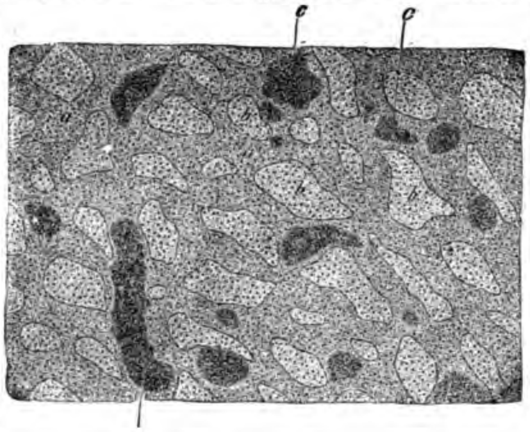


FIG. 269.—Vessels of the Area Pellucida of a Chick of Two Days. *a, a,* Vessels; *b, b,* interstitial tissue; *c, c,* blood islands. (After Kölliker.)

He found in the subcutaneous tissue blood islands, which are produced from connective-tissue cells in the following manner:

"A part of the protoplasm of the cell acquires a reddish tinge, and after a time the colored substance becomes

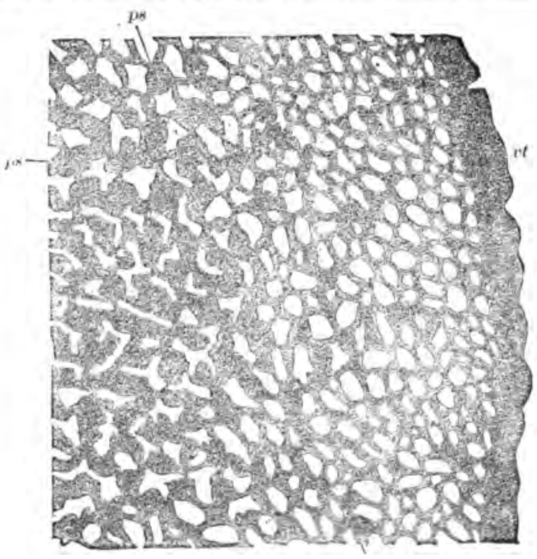


FIG. 270.—Part of Area Vasculosa of Embryo Chick of Forty Hours. × 26 diameters. (After Kölliker.) Only the vascular network is drawn, *ps*, and the terminal sinus or vein, *vt*.

condensed in the form of globules within the cells, varying in size from a minute speck to a spheroid of the diameter of a blood corpuscle, or even larger; but gradually the size becomes more uniform. . . . After a time the cells become elongated and pointed at their ends, and processes grow out to join prolongations of neighboring blood-vessels or of similar cells. At the same time vacuoles form within them, and becoming enlarged coalesce to form a cavity filled with fluid, in which the reddish globules, which are now becoming disc-shaped, float." Corpuscles formed thus by a process akin to secretion cannot be regarded as homologous with the corpuscles that are formed by the metamorphosis of nucleated cells in the early stages of the embryo and in the adult. This process of intracellular blood formation does not receive confirmation, however, from the studies of Saxer, who found similar blood islands in the subcutaneous tissue of the newly born sheep. According to his account, these islands arise by the repeated mitotic division of giant cells. The corpuscles are at first nucleated and subsequently lose their nuclei as they do in the adult.

Returning now to the area vasculosa, we find in the chick of the second day that the vessels form a coarse network (Fig. 270), without any indication of large stems or trunks, except the broad limiting sinus, *vt*, which marks off the edge of the area. There is only one layer of vessels. Scattered about in the network are irregular red spots, which received from early embryologists the name, still current, of blood islands. At first the network consists of solid cords of cells, but the cords soon become hollowed out as described above.

Soon after the capillary network of the area opaca and area pellucida has penetrated the embryo, certain lines of the network begin to widen, and soon distinctly assume the size and functions of main trunks; some of these unite with the posterior venous end of the heart, which has meanwhile been formed in the embryo, and others become connected with the anterior or aortic end; even before this the heart has begun to beat, so that as soon as all the connections are made, the primitive circulation starts up. The arrangement of the vessels is not the same in birds and mammals, although commonly so stated. The disposition in birds is indicated by the diagram shown in Fig. 271, in which, it should be remembered, the embryo and the capillary network are drawn many times too large in proportion to the *area vasculosa*. The area is bounded by a broad circular vessel, the sinus terminalis, S.T., which constitutes a portion of the venous system in birds, for in front of the head of the embryo the sinus leaves a gap and is reflected back along the sides of the body of the embryo, to make two large veins, which, after uniting with other venous channels coming from various parts of the area vasculosa on each side, enter the embryo as two large trunks, Om.V.,

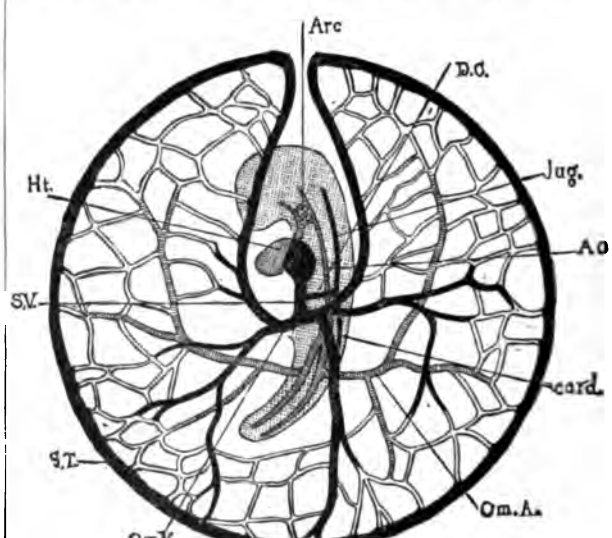


FIG. 271.—Diagram of the Circulation in a Chick at the End of the Third Day, as seen from the Under or Ventral Side. The embryo, with the exception of the heart, *Ht.*, is dotted; *Arc.*, aortic arches; *D.C.*, ductus Cuvieri; *Jug.*, jugular vein; *card.*, cardinal vein; the remaining letters are explained in the text. The veins are black; the arteries cross-lined. (From Minot.)

known as the *vitelline veins;* these two veins unite in a median vessel, the *sinus venosus*, S.V., which runs straight forward and enters the posterior end of the heart. The

ently not active. Areca also contains fourteen per cent. of fixed oil, much tannin, and some resin. Although the tænicidal properties of areca reside in the arecoline, which is given to horses for this purpose in doses of 0.03 to 0.06 gm. (gr. ss. to i.), this dose acting also as a cathartic, it is too poisonous for use in human practice. A solution of one-per-cent. strength is instilled into the human eye as a myotic.

Powdered areca is frequently given as a tænicide, in doses of 8 to 12 gm. (ʒij. to iij.). It also acts as an astringent, so that the usual accompaniment of a cathartic must be resorted to. *H. H. Rusby.*

ARGEMONE.—*Mexican Poppy.* Of these plants the most important thing that can be said is that they are eminently worthy of careful investigation. They were formerly regarded as constituting but a single species, but are now known to represent several. Of these, it is not certainly known which supplied the material upon which previous studies were based, so that we are able to speak only of the group in general. They are very widely distributed through the tropical and warm parts of America, as well as widely introduced into Africa and tropical Asia. The plants are of striking appearance, two or three feet high, with large, broad, glaucous, prickly-toothed leaves, large poppy-like white or yellow flowers and prickly capsules. On being wounded, they exude a thick yellow juice. They grow in great abundance in waste places and over dry sterile soil. They have been used medicinally in the form of an extract of the whole plant, of the expressed juice, of the seeds, and of the oil expressed from the seeds. The juice has been ignorantly used in venereal diseases, and instilled into the eye for conjunctivitis. This juice contains in very small amount an alkaloid which is believed to be morphine. The fixed oil of the seeds, yielded to the extent of about thirty-six per cent., has received the most attention. It has been clearly shown to be mildly cathartic, without bad effect, in doses of four to five grams, and to form a tasteless and not unpleasant substitute for castor oil. Taken in larger doses it and the seeds are emetico-cathartic, with the symptoms of local irritation.

H. H. Rusby.

ARGYRIA, ARGYRISM, ARGYROSIS, ARGYRIASIS—the terms applied to the discoloration of the skin and certain other tissues of the body resulting from the long-continued medicinal use of soluble silver salts, and caused by the deposit in the affected tissues of metallic silver, or some of its lower compounds, in a state of minute subdivision.

Clinically the condition is characterized by a slaty or grayish-brown, or in the most severe cases, by a bluish discoloration of the skin, conjunctivæ, and visible mucous membranes. The internal organs, with the exception of the central nervous system, suffer a similar pigmentation. The discoloration of the skin appears to vary in different regions, being less intense where the horny layer is thick, as in the palms of the hands and soles of the feet; and of greater intensity where the horny layer is thin. The hair and nails are not affected, but the bed of the latter is usually deeply pigmented. Scars formed before or during the period when the silver was taken are pigmented, but those formed after the cessation of its use remain white. The apparent intensity of the pigmentation also varies with the temperature of the surface of the body, being most marked in the cold, and greatly decreased when the skin is warm and flushed.

The pigmentation increases as long as the internal use of the silver salt is kept up. Its degree and extent are in direct proportion to the amount used and the period of time through which its administration is extended. It is essentially a chronic process. The discoloration never disappears, and it is doubtful if the silver deposit is ever removed from the body, though it has been claimed in a number of instances that after the lapse of years a decrease of the color has taken place. (See author's case mentioned below.)

The condition has been known since the alchemistic period when the internal use of silver salts was very popular, and descriptions which undoubtedly refer to argyria exist in the literature of that time. The first case mentioned in medical literature is the one observed by Schwediauer and reported by Fourcroy in 1791. In the early part of the nineteenth century numerous cases were described, and the number of these increased greatly about the middle of the century when the use of silver nitrate in epilepsy and tabes reached its greatest popularity. At that time a generation of individuals affected with argyria may be said to have arisen, and frequent examples of the condition came to the post-mortem tables of the great European hospitals. That generation has now practically disappeared, and cases of general argyria resulting from long-continued use of silver salts are to-day of very rare occurrence. The present cases of argyria are for the greater part localized discolorations resulting from local medicinal applications of silver nitrate, or from absorption through the skin or respiratory tract of silver dust, as in the case of workmen who file, grind, or polish the metal. Three forms of argyria may be distinguished clinically: *argyria universalis, argyria localis circumscripta, argyria localis disseminata.*

Argyria Universalis.—The condition of universal pigmentation of the skin and mucous membranes is caused by the long-continued internal use of silver nitrate. The discoloration develops independently of any pre-existing condition of the skin or body tissues, and its intensity is in proportion to the amount of silver absorbed and the period of time covered by its administration. As a rule the pigmentation appears several months after the use of the silver is begun, and develops slowly. As the discoloration is usually not observed until it has reached a certain degree of intensity, it is impossible to speak with certainty of the exact course of the pigment deposit. It has been claimed that a blue or violet line on the gums is the earliest symptom, but this does not occur in all cases. The degree and extent of the pigmentation of the skin varies in different cases: the face, thorax, and abdomen may show it earliest and to the greatest degree, while the extremities may remain unaffected. The mucous membranes may show no discoloration in intense argyria of the skin; while on the other hand a marked degree of pigmentation may exist in the internal organs without any great change in the skin. A metallic odor of the breath accompanied by a stomatitis with or without salivation has been described, but the occurrence of these symptoms is very rare or doubtful. There are no symptoms coincident with or following the condition that can be said to be the direct result of the deposit of the pigment.

The total amount of silver nitrate which must be taken in order to produce a well-marked case of argyria varies greatly, the lowest limit being placed at 25 to 30 gm. The administration of the metal must be extended through a considerable period of time. Large doses given within short periods produce symptoms of poisoning without the deposit of pigment, while minute doses administered for many months or years produce the most intense discoloration. Liouville reported a case in which the total amount of silver nitrate used was only 7 gm., but there resulted an intense argyria of the internal organs, the skin over the abdomen alone being slightly discolored. The same writer also claimed to have seen in another case the appearance of the blue line on the gums after the use of thirty pills each containing 0.01 gm. of silver nitrate. The skin in this case was not affected. It is, of course, evident that it is the amount of silver absorbed and not the amount taken into the body that influences the degree and extent of pigmentation. With the minute doses of silver nitrate now given and the relatively short periods of administration there is but little danger of the production of argyria; but if the salt is given for any considerable period, the possibility of its occurrence must always be borne in mind and the patient duly informed.

A general argyria may also be produced by the local absorption of silver nitrate, as in the long-continued use

changed by the stomach and intestinal juices into a soluble silver albuminate, which is absorbed from the intestines into the circulation and is ultimately passed with the lymph through the walls of the blood-vessels into the tissues, where it is precipitated in the form of fine granules.

Opposed to this view is the theory supported by Virchow and Riemer that the silver nitrate is reduced in the intestinal tract and taken up from the latter place in the shape of fine granules, partly through the lymph and partly through the blood, into the general circulation, where by metastasis these are deposited in various parts of the body. Jacobi showed that the reduced particles of silver cannot penetrate the epithelium of the intestine,

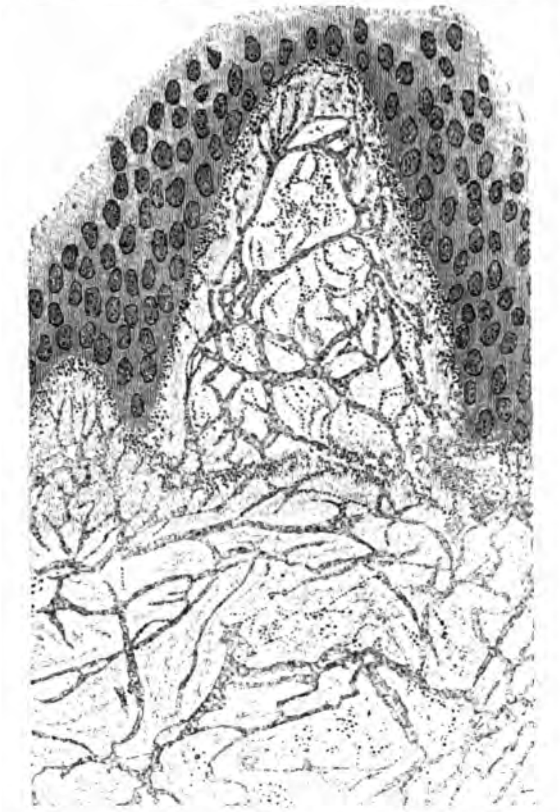


FIG. 273.—Section of Silver Spot of Skin from Case of Disseminated Argyria (silver-workers' argyria). (After Lewin.)

and further proved experimentally that the greater part of the silver nitrate taken into the body is not reduced in the intestine, but is changed to silver chloride and albuminate, and absorbed as such, the reduction taking place in the tissues. Loew held that the reduction of the silver held in solution in the circulating blood is the result of the action of living cell-protoplasm, most probably that of the endothelium. On the other hand, Kobert holds that the reduction takes place only in certain organs—the liver, kidneys, papillæ of skin, and intestinal wall—and that the reduced silver is carried elsewhere by leucocytes, for the greater part to the spleen, lymph glands, and bone marrow, where it is ultimately deposited in the connective tissue. Through the agency of the wandering cells containing silver granules a part of the silver may be removed from the body. The reduction in the wall of the intestine he holds to be due to the absorption by the intestinal wall of certain gases, hydrogen and hydrogen sulphide, which are formed in the intestinal tract by the growth of anaërobic germs, the hydrogen leading to a reduction of the silver, and the hydrogen sulphide to the formation of a silver albuminate suphide. The reduction of the silver in the papillæ of the skin Kobert holds to be due to or associated with the process of cornification, which he regards as a reduction process. He explains the fact that argyria in human skin is of so much more constant occurrence than in the skin of animals by the assumption that the process of cornification takes place to a much greater degree in human skin. This theory, however, does not receive the support of the actual facts.

In the light of our present knowledge the most reasonable hypothesis is that the silver is absorbed from the intestine into the general circulation in the form of a soluble albuminate which is taken out of the blood and reduced by the protoplasm of the endothelial or perithelial cells, and secreted by these cells into the neighboring connective tissue, where it may remain or be further transported by means of wandering cells. The deposit of the silver in certain parts of the body cannot be explained by the theory of simple metastasis, and as it has been established beyond doubt that the endothelium in different parts of the body has a selective action, it seems to the writer that the best hypothesis for the explanation of the pathogenesis of argyria is the theory of endothelial-cell activity.

The chemical nature of the fine silver granules in the tissues has not as yet been definitely determined. According to Kobert, the pigment is a loosely held organic compound of silver and presents the following reactions: the granules are insoluble in acetic and dilute mineral acids, fixed alkalies and ammonia; they lose their black color but do not vanish in strong nitric acid and in moderately strong solutions of potassium cyanide; the black color may be restored by means of hydrogen sulphide. Substances which decolorize the organic pigments have no effect upon the silver granules. If a piece of tissue heavily pigmented with silver is warmed with nitric acid until it loses its color and the acid then filtered off, the filtrate will contain no silver, the metal remaining in the decolorized tissue. Other investigators hold that the pigment is metallic silver or a low oxide (AgO_2 or AgO_4).

The amount of silver deposited in the tissues is very small compared to the amount taken into the body. Experimental analyses of tissues showing a high degree of argyria have yielded only minute quantities of silver. Frommann obtained from 760 gm. of liver which had been preserved in alcohol only 0.009 gm. of silver chloride, equalling 0.0068 gm. of metallic silver. Versmanns found the same amount of metallic silver in 14.1 gm. of dried liver, and in 8.6 gm. of dried kidney 0.053 gm. of the metal.

Since the silver pigment is deposited in the connective tissue outside of the vessels, its complete removal during the life of the affected individual is very improbable. Through the agency of wandering cells a very slow removal may take place, but it is doubtful if in well-marked cases this leads to any noticeable decrease in the degree of pigmentation. Cases of recovery have been reported, but they are doubtful. Rogers affirms that blistering will lighten the color very much, and Eichmann claims to have produced a cure by means of potash baths. Yandell has reported two cases in which large doses of potassium iodide were given in connection with mercurial vapor baths for several months in the treatment of syphilis with complete cure of the existing argyria, the pigmentation fading very gradually. In spite of these reported cures the great majority of cases are unaffected by treatment, and the affected individual carries his pigmentation to the end of his life. In cases similar to the one reported by the writer in which the argyria is produced at an early period of life before puberty, the later increase of tissues may lead to an apparent decrease in the intensity of the pigmentation.

Aldred Scott Warthin.

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ARISTOL—$C_{20}H_{24}O_2I_2$, is the registered trade name of dithymoldiiodide. The pure drug has been introduced to the profession under the title *Thymol Iodid* to escape the registered name. It is prepared from thymol, $C_{10}H_{13}HO$, by substituting two molecules of iodoxyl, IO, for two of hydroxyl, HO. It contains forty-five per cent. of iodine. A moniodide and a triiodide have also been prepared. The latter has been called *annidalin*, and is used for the same purposes. Aristol may be made as follows: one and a quarter drachms each of thymol and caustic soda and one and a half drachms of potassium iodide are gently heated with enough distilled water to make one ounce four and a half drachms, and then cooled. This solution is added to eight ounces of a concentrated solution of hypochlorite of soda and agitated. The solution is then filtered, and the precipitate washed with water and dried.

It is a light, reddish-brown powder, with a very faint odor, insoluble in water and glycerin, slightly soluble in alcohol, soluble in ether, collodion, and oils. It should be carefully preserved, as it is decomposed by light and heat.

Therapeutically it is recommended for the same purposes as iodoform, but it is less active and not so reliable as an antiseptic in surgical work. Its advantages are that it is devoid of the disagreeable odor, and does not possess the toxic properties of the latter drug. It has been used in the treatment of eczema, psoriasis, scabies, chronic inflammation of the mucous membranes of the nose and pharynx, erosions of the os uteri, condylomata, granulating wounds, and ulcerating surfaces. It possesses the power of causing rapid cicatrization in a marked degree, and has proved of greatest service in the latter class of cases, particularly in the treatment of burns and varicose ulcers. In lupus, tuberculous and syphilitic ulcerations it was supposed to possess specific powers, but experience has not supported this view.

The powder is best applied by dusting on the part, or by insufflation; it may be used as an ointment, one part in ten, or dissolved in ether or collodion.

As it is partly eliminated through the lungs, it has been used in phthisis by hypodermic injections of a one-per-cent. solution in sterilized oil of sweet almonds. It is said to lessen the cough and night sweats.

Beaumont Small.

ARISTOLOCHIACEÆ.—(*The Serpentaria Family.*) A small family of some five genera, widely distributed over the warm parts of the earth. A species of aristolochia produces one of the largest of known flowers, some five feet in length. Many species have been ignorantly reputed as antidotes to serpent poisons. Medicinally, the family, rich in volatile oils and resin, is well represented by Virginia, Texas, and Canada snake roots. Many species are used in native practice as vulneraries.

H. H. Rusby.

ARIZONA.—The climate of Arizona, being influenced both by the Rocky Mountains and by the Pacific Ocean, has some of the attributes possessed by the climate of New Mexico and also some of those belonging to the climate of Southern California; and, moreover, it has distinct climatic advantages different from those of any other State. The plain country of Arizona has not inaptly been called the Egypt and sometimes the Persia of America. The great continental divide traversing the western boundaries of New Mexico, along the 108th meridian of longitude, passes almost in a straight line from north to south. Westward of its summit the streams flow toward the Pacific Ocean, and the land drops down to the southwest corner of the Territory of Arizona by a series of steps with wide intervening plateaux.

A second great divide separates the waters of the Gila and Colorado rivers. Its main direction is along latitude 35°. Starting from the point where latitude 34° meets the New Mexican boundary, it crosses the territory till the San Francisco Mountains north of Flagstaff are reached. The main direction of the mountain axis of Arizona is from northwest to southeast. "The axis of the mountain system of Arizona is remarkably well defined and appears with the utmost distinctness, not only in the general trend of the main mass of the elevation, but also in minor ranges and notably in detached spurs, often widely separated from the plateau system, to which, on the score of altitude, they may claim to belong."*

From the valley of the Rio Santa Cruz, starting from a mesa 2,000 feet high, no less than fifteen peaks ascend to an altitude of upward of 8,000 feet. In the Gila valley, springing from benches of 1,000 to 3,000 feet elevation, are a dozen buttes from 1,000 to 2,000 feet in height. From a plateau of 5,000 feet mountains rise from 7,000 to 9,000 feet in height, the highest being a group called the San Francisco Mountains with its three peaks—Humphrey, Agassiz, and Humboldt—which approximate an elevation of 13,000 feet above sea-level.

The air of Arizona receives its humidity almost entirely from the Pacific Ocean. The prevailing southwest winds, laden with moisture from this vast expanse of salt water, strike the broadside of the elevated land at a right angle, because of the uniform trend of the mountain axis, so that "the passage of the rainy winds across Arizona is by no means an easy gliding over an inclined plane, but the laborious ascent of a flight of steps" (Captain W. A. Glassford).

The variations in the meteorological conditions of Arizona are much influenced by its topography, which is conveniently arranged under three divisions: the plain, the pro-plateau, and the plateau.

The Plain.—"This embraces about one-third of the territory which lies to the south and west below the level of 3,000 feet, and includes most of the desert country that has given Arizona its unenviable reputation for heat and discomfort. On this low plain the rainfall is only from two to six inches during the year, and, including the desert on the California side of the Colorado River, the records approximate the absolute minimum of rainfall of the world."†

Here we have a striking resemblance to the valley of the Nile: rivers with rich alluvial soil along their bottoms, where under irrigation all kinds of crops and fruits will grow; while on their borders is the dry, sandy, soil of the desert. This plain country is too hot in summer save for those who in their habits resemble the salamander. In winter, on the other hand, the genial warmth, the brilliant sunshine, the rainless skies, and moderate elevation give a climate as delightful as that of the far-famed countries of Egypt and Persia.

The pro-plateau stands at an elevation of from 3,000 to 5,000 feet. "It closely follows the axial inflection of the mountain system, although its continuity is somewhat interrupted by the more or less detached spurs of its higher neighbor. Across the central portion of the Territory it preserves, with considerable uniformity, a mean width of less than 100 miles. Widening at the cañon of the Gila, it covers the whole southeastern corner of the Territory" (Captain Glassford). In this latter portion of the pro-plateau are mountains which rise to a height of 2,000 feet above it, and which exert a powerful influence upon the precipitation. In this region the country is greener, more picturesque, with mountain cañons and valleys, and a greater rainfall than in the plain country. The plateau covers more than half the Territory, having

* Report on the climate of Arizona by Captain W. A. Glassford, Signal Corps, U. S. A., 1890.
† "Handbook of Climatology," S. E. Solly, M.D. Lea Brothers, Philadelphia, pp. 288–289.

an average elevation of 5,000 feet. On account of the two mountain systems near which it lies, this division is the one in which the rainfall is heaviest, being from ten to twenty inches.

Arizona differs from New Mexico and Colorado in that it has two rainy seasons. The summer rains which fall during July, August, and September are local in character, due to the influence of the mountains; they usually occur in the form of heavy afternoon showers, during which an inch of rain will not infrequently fall.

In October and November the rains do not altogether cease, but are light and infrequent. The winter rainy season begins in December and terminates in February.

"These rains are caused by the proximity of approach of great storms in low-pressure areas which form a part of the storm system of the country at large. . . . They are moderate in force and are interrupted by the anticyclonic types of high barometer and cloudless skies which are distinctive of the Pacific coast weather" (Captain Glassford).

Most of the precipitation on the mountains comes in the form of snow, and it remains there till summer; but on the plains it usually manifests itself as rain.

March, April, May, and June form the one dry season. This is in marked contrast to the spring weather of New Mexico and Colorado, which is comparatively moist. The winter rainfall is less than one-half of that of the summer season.

The number of cloudy days throughout the year, especially in the autumn, is about equal to that of New Mexico and Colorado, but in the plain country the number is decidedly less.

The wind movement is very small, especially on the plain.

"The belt of 50° F. or less mean annual temperature includes the northeast corner of the Territory above Fort Defiance. In the southern half of the Territory the mean temperature of 60° F. or more shades into the heat of the desert, with a mean annual temperature of about 70° and a monthly mean for July of 90 F." *

The night temperatures in the plain country are high, increasing the objectionable features of the summer climate for most invalids; and the dust which is irritating and abundant, is more particularly so in the summer, so that throughout the territory of Arizona the summer heat is peculiarly trying, except at an elevation of 7,000 feet and upward, when the altitude exerts more influence upon the temperature than does the latitude. It is not, however, fair to estimate the effect of the heat entirely by the height of the thermometer, because what Prof. M. W. Harrington has happily termed † "sensible temperature" has to be taken into consideration.

"The published temperatures for the different weather stations are the readings of the ordinary dry-bulb thermometer. The influence of evaporation is shown by what is called the wet bulb thermometer, the bulb having a covering of cotton or muslin which is kept moistened. The consequent evaporation from the surface of this wetted bulb is similar to that of the human body from which the perspiration is evaporated, thus causing coolness. The temperature shown by the wet-bulb thermometer is called the 'sensible' temperature, and is supposed to be the temperature felt at the surface of the skin. As a matter of fact, it is probably lower, because the cloth covering the wet bulb is continuously saturated with water, while the surface of the skin is usually but slightly moistened, and is not subjected to such rapid evaporation. The wind is an important factor in sensible temperature, because if the air is in motion that portion which is in contact with the human body is continuously replaced by dry air, while if the air is stationary it becomes slightly warmed and more humid from heat and moisture of the body, and the amount of evaporation from the surface of the skin is necessarily less. The amount of the reduction or cooling of temperature is in

* "Handbook of Climatology," Solly, pp. 282.
† Prof. M. W. Harrington: Transactions of the American Climatological Association, 1894.

direct ratio to the dryness of the air. It will be greatest where the air is driest, least where the air is most moist. The greater the depression of the dew point below the ordinary or shade temperature, the less the relative humidity; the drier the air, the more rapid the evaporation and the greater the consequent reduction of temperature. . . . This is true of all arid regions, where the difference between the dry and wet bulbs during the warmest and driest portion of the day will range from 20° to 40° F. or more." *

The great drawbacks to the present use of Arizona by invalids are the scarcity of the resorts and the generally indifferent character of the accommodations. The chief resorts at present available are given in the order of their elevation above sea level:

Yuma, elevation 140 feet, population 1,200, lies in the great Arizona desert on the banks of the Colorado River, some sixty miles from the Gulf of California. The winter climate is peculiarly mild, dry, warm, and pleasant, and it is here that the benefits of desert air are best exhibited: but, unfortunately, the accommodations and resources are at present not worthy of the climate. The summer climate is far too hot for most invalids.

Phœnix, elevation 1,100 feet, population 10,000, is placed about two miles from the Salt River and is the largest and most important city in Arizona. It has good hotels and accommodations and the general resources of a prosperous Eastern city. The broad streets are shaded by trees and the houses are surrounded by grass lawns. It has an agreeable winter climate, with the least wind movement, perhaps, of any resort of like elevation. Being a little higher, it is not quite so hot as Yuma, and also is not quite so dry, because of the extensive irrigation which goes on in the Salt River valley in which it is situated; but it is admirably adapted for winter residence for patients to whom a warm dry climate without altitude is suited.

Tombstone, elevation 2,300 feet, population 2,500, is situated on a high bench overlooking the San Pedro River. Its winter climate is good; its accommodations are only moderate.

Tucson, elevation 2,400 feet, population 6,000, being higher is more bracing and cooler than Phœnix, and combines the advantages of desert air with slight altitude. It is a thriving city with fair accommodations.

Castle Creek Hot Springs, elevation 2,300 feet, is a small settlement with good accommodations and fine bathing facilities. It lies in a spur of the Bradshaw Mountains and is a four hours' ride from the Santa Fé, Prescott and Phœnix Railway. Its winter climate is said to be very agreeable, but weather reports are not at present available.

Oracle, elevation 4,500 feet, is a small settlement of a few ranches where boarders are taken, and the accommodations are plain but good. It is a forty miles' stage ride over a good road from Tucson. The pine-clad mountains afford shelter from the north. It is free from dust and cooler and more bracing than Tucson, and is a beautiful country which is pleasant to ride through.

Prescott, elevation 5,300 feet, population 3,000, lies sixty miles from Ashfork upon the Santa Fé, Prescott and Phœnix Railway. It is surrounded by beautiful mountain scenery, and has adjacent high benches with pines and sandy soil where the residences should be; but the town is unfortunately situated on adobe soil in the river valley, and the accommodations are indifferent. The climate, however, is excellent, resembling that of Denver, combining the advantages of upland air with the warmth which comes from its low latitude. The temperature range and wind movement are much greater than at the places previously mentioned.

The appended tables are abstracted from the author's paper on the "Comparative Merits of Resorts in New Mexico, Colorado, and Arizona," presented to the American Climatological Association.†

S. E. Solly.

* "Handbook of Medical Climatology," pp. 62–63.
† Transactions of the American Climatological Association for 1897.

ANNUAL AVERAGES.

	Elevation.	Latitude.	Soil.	Normal air pressure.	Temperature. Annual.	Temperature. January.	Temperature. July.	Humidity. Relative humidity.	Humidity. Absolute humidity.	Humidity. Dew point.	Humidity. Rainfall.	Number of cloudy days.	Mean monthly wind movement.
Colorado Springs, Col	6000	38.51	Gravel	24.03	47	26	69	50	1.84	29	14.4	57	6666
Prescott, Ariz.	5300	34.33	Sand and adobe	24.76	53	34	74	51	2.31	35	16	51	4898
Oracle, Ariz.	4500	32.50	Gravel	....	63	45	80	22 *	....	26 *	17.7	..	....
Las Cruces, N. Mex.	3800	32.17	Adobe	26.11	58	39	77	65 *	...	47 *	7	20	4948
Tucson, Ariz.	2400	32.14	Sand and gravel.	27.45	69	50	88	42	3.25	44	12	57	3735 *
Phœnix, Ariz.	1100	33.28	Adobe.	28.77	69	49	90	45	3.5	42	7	52 *	3379
Yuma, Ariz.	140	32.44	Sand	29.92	72	53	92	46	3.19	43	2.9	15	4317
Cairo, Egypt	90	30.31	Sand	....	72	54	86	61	5.42	58	.53	..	....

* 1896.

	Spring Seasonal Averages. Seasonal temperature.	Night temperature.	Relative humidity.	Absolute humidity.	Rainfall.	Number of cloudy days.	Hourly wind movement.	Summer Seasonal Averages. Seasonal temperature.	Night temperature.	Relative humidity.	Absolute humidity.	Rainfall.	Number of cloudy days.	Hourly wind movement.
Colorado Springs, Col	49	32	46	1.81	4.5	20	11.8	67	51	50	3.62	7.2	11	8
Prescott, Ariz.	51	36	44	1.86	3.1	7	8.4	70	56	48	3.83	6.1	9	7.2
Oracle, Ariz.	60	48	..	....	1.5	..	....	78	68	..	...	6.5	..	....
Las Cruces, N. Mex	58	..	..	....	.4	18 *	....	76	..	..	....	4.7	21 *	....
Tucson, Ariz	62	47	37	2.27	1.2	5	5.3	82	69	40	4.65	5.4	12	5.1
Phœnix, Ariz.	67	..	33	2.23	.3	7	5.6	87	..	41	5.55	2.7	10	4.8
Yuma, Ariz	70	54	43	3.43	.3	4	6.7	89	73	43	6.18	.5	3	6.6
Cairo, Egypt	74	..	52	4.94	.13	..	....	86	..	51	6.84	..	..	....

* 1896.

	Autumn Seasonal Averages. Seasonal temperature.	Night temperature.	Relative humidity.	Absolute humidity.	Rainfall.	Number of cloudy days.	Hourly wind movement.	Winter Seasonal Averages. Seasonal temperature.	Night temperature.	Relative humidity.	Absolute humidity.	Rainfall.	Number of cloudy days.	Hourly wind movement.
Colorado Springs, Col	48	34	54	2.05	2.0	13	8.2	29.0	17	50	0.94	0.7	13	8.4
Prescott, Ariz.	53	37	49	2.21	2.7	4	5.9	35	27	57	1.4	5	8	6.3
Oracle, Ariz.	65	54	..	....	5.6	..	...	45.2	37	..	...	4.1	..	....
Las Cruces, N. Mex	59	..	..	....	1.5	12 *	....	43	..	43	1.37	1.17	11 *	....
Tucson, Ariz	68	51	43	3.22	2.4	4	5.1	49	35	48	1.89	3	11	5
Phœnix, Ariz.	69	..	56	4.4	1.7	7	4.4	51	..	53	2.2	2.6	11	4.4
Yuma, Ariz.	73	57	46	4.04	.7	3	5.1	56	43	47	2.36	1.6	6	6.1
Cairo, Egypt	73	..	70	6.32	.3	..	....	58	..	70	3.57	....	..	....

* 1896.
The wind and humidity of Phœnix are based on one year only.

ARM, THE.—The *arm* begins at the lower anterior margin of the axilla—the lower border of the pectoralis major muscle—and ends at the elbow joint, where the joint capsule joins the humerus before and behind.

The *skin* of the arm is similar in structure to that of other uncovered skin surfaces of the body, is thin, especially at the front and sides, loosely attached to underlying structures, and is free from large hairs.

The *superficial fascial layer* contains fat tissue that rounds out the contour in the well-nourished, and especially in the female and female art figure.

The *brachial fascia* (deep fascia) is derived from the deep fascia of the pectoralis major in front, and from the insertions of the teres major and latissimus and their sheaths behind; from a prolongation of the deltoid fascia on the outer side, and, through the axillary fascia, from the deep fascia of the serratus magnus, upon the inner side of the arm. Coming together from these origins these fasciæ join to form a thin but firm sheath from shoulder to elbow. Arising from the external condylar ridge of the humerus and passing outward to meet this sheath is the external intermuscular septum, which extends from the condyle to the deltoid tubercle. Arising from the internal condyle and the internal condylar ridge, and extending from the coraco-brachialis insertion to the elbow, is the internal intermuscular septum. These two septa divide the arm into two regions, the *front* and the *back*.

The *front compartment* of the arm contains biceps and brachialis; the coraco-brachialis being added at an upper-third arm section, and the brachio-radialis, and to a certain extent also the extensor carpi radialis longus, at a lower-third arm section.

The *back compartment* contains triceps and anconeus.

These compartments contain also their respective blood and nerve supplies. The musculo-spiral nerve passes backward, downward, and outward, with its accompanying superior profunda artery, through the interseptal space between the internal and external heads of the triceps, from a point high up in the back compartment. The musculo-cutaneous nerve passes forward, downward, and outward from the brachial plexus in the axilla, through the coraco-brachialis and between the biceps and brachialis above in the front compartment, the brachial artery supplying this compartment throughout. Still lower down in the arm, above the elbow, we have practically in the external intermuscular septum, the musculo-spiral nerve and the superior profunda artery, and within the enfolding of the internal intermuscular septum, the ulnar nerve and the inferior profunda artery.

The conformation of the front of the arm is due to the form of the biceps, which rounds well forward. At the slight groove at the inner and outer base of the biceps are placed respectively the basilic and cephalic veins, which extend from their anastomoses at the elbow upward along

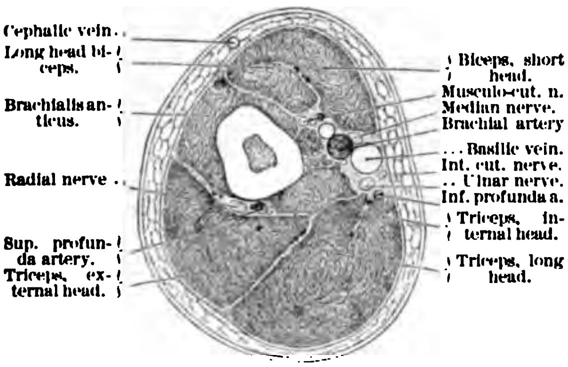

FIG. 274.—Transverse Section of Arm just below Insertion of Deltoid. (From Joessel: "Lehrbuch der topographisch-chirurgischen Anatomie," Bonn, 1884.)

the borders of the biceps to join their outlet, the axillary veins, at the inner and outer sides of the arm and shoulder.

In association with the skin we find, forming the cutaneous supply of the outer arm, from the shoulder to the wrist: circumflex, upper external cutaneous branch of the musculo-spiral, lower external cutaneous branch of the musculo-spiral, and cutaneous branches of the musculo-cutaneous. In the skin and superficial fascia of the inner arm and forearm is the cutaneous supply of the inner arm and forearm: intercosto humeral, internal cutaneous branches of the musculo-spiral, lesser internal cutaneous (Wrisberg's), and internal cutaneous.

A few small lymphatic nodes upon the inner side of the arm, just above the elbow, may be found in the superficial fascia near the course of the basilic vein.

The lowest point of the insertion of the deltoid marks the middle of the humerus, the middle of the musculo-spiral groove behind, the lower border of the coraco-brachialis insertion, and the upper limits of the brachialis.

THE FRONT OF THE ARM.—Just within the anterior fascial compartment is the biceps, which lies upon the brachialis, while the latter, in turn, lies upon the anterior surface of the humerus. Along the inner border of these two muscles is the brachial artery. The artery winds about the humerus from the mid-axillary space, high up in the arm, to the internal septum in the mid-arm, to the anterior part of the brachium at the elbow. The terminal branches of the brachial plexus also conform to this route through the arm.

The *biceps* arises from the scapula by two heads: the long head above the glenoid fossa of the scapula, the short head, in common with the coraco-brachialis, from the tip of the coracoid process. From these two tendinous origins, these heads swell into long muscular bellies that converge and lie side by side in the upper third, and unite at the lower third of the arm. Toward the bend of the elbow the muscle fibres converge upon a centrally placed short, stout tendon, which is inserted upon the posterior facet of the tuberosity of the radius, a bursa occupying the anterior facet over which the tendon plays when the forearm is flexed. The fascial sheath of the arm anteriorly, after becoming distributed to bony parts of the elbow and condylar ridges, receives in front of the elbow a strong, flattened band of fibres from the biceps tendon, the semilunar or bicipital fascia, which is continuous with the deep fascia above and is lost over the pronator teres below in the ulnar fascia. This fascia bridges over the brachial artery and separates it from the median basilic vein.

The *brachialis* arises from the whole lower half of the inner and outer surfaces of the humerus, from the front of the internal intermuscular septum, and from a part of the external intermuscular septum above a point where the musculo-spiral nerve pierces it. Its origin embraces the insertion of the deltoid. The muscular fibres converge broadly into a short, thick, tendinous insertion upon the coronoid process. This muscle is overlaid by the biceps, but projects beyond it inward and outward. It is overlapped on the inner side by the brachial artery, by the median nerve, and by the pronator teres; also, deeply, by the anterior branch of the anastomotica magna and the anterior ulnar recurrent artery. Upon its outer side it is overlapped by the radial recurrent artery, by the radial nerve, and by the brachio-radialis and extensor carpi radialis longus; also deeply, by the musculo-spiral nerve and by the terminal branch of the superior profunda artery.

The *coraco-brachialis* is an elongated muscle arising in common with the short head of the biceps from the tip of the coracoid process. It is inserted on the inner border of the shaft of the humerus at about its middle. It lies, in its lower part, along the inner border of the biceps, the two muscles lying to the outer side of the brachial artery.

The *brachial artery* is the direct continuation of the axillary at the level of the lower border of the teres major. Therefore the lower half of the third portion of the axillary artery lies uncovered by muscle in the upper arm. The brachial extends a short distance below the elbow where it ends in its two terminal branches—the radial and ulnar arteries—on opposite sides of the radius near the junction of its head and neck. The course of the artery is sinuous; it lies at first internal to the humerus, then in front of the bone, and, at the bend of the elbow, midway between

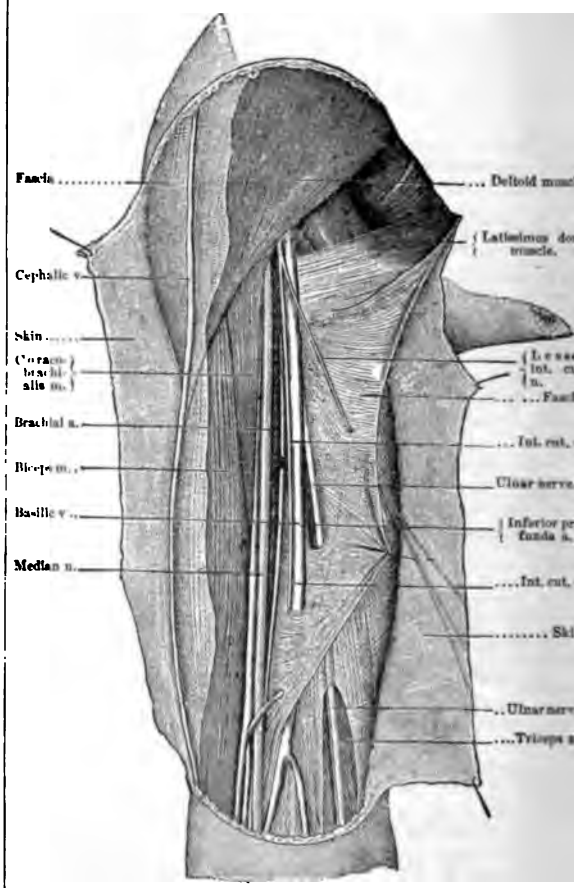

FIG. 275.—Dissection of the Arm, Anterior and Internal Surface. The skin and fasciæ have been turned back. (From Joessel.)

the condyles. Compression of the artery at any point in the arm should be outward toward the bone above, outward and backward at its lower third, directly backward

below. Throughout its course the artery occupies a position near the surface. It lies at first upon the long head of the triceps, but is separated from the muscle by the musculo-spiral nerve and superior profunda artery, and is overlapped by the biceps. Next, it rests upon the inner head of the triceps, at the middle third of the arm, and is overlapped by the insertion of the coraco-brachialis. At its lower third, just before bifurcation, it lies upon the brachialis. It lies beneath the skin and fascia and is partially bridged over by the coraco-brachialis and biceps upon its outer side. At the bend of the elbow it is overlapped again by the strong bicipital fascia, is crossed by the median basilic vein, and dips deep into the triangular (anticubital) space between the brachio-radialis and the pronator teres. The sheath of the artery is closely incorporated with the deep fascia of the biceps, so that in ligation of the artery it moves in its position according as tension is put upon the muscle.

The *median nerve* follows closely the artery and its sheath, lying first to its outer side, then in front of it, and finally toward the elbow at its inner side. The *ulnar* and the *internal cutaneous nerves* lie to the inner side of and behind the artery till about the middle of the arm, when the ulnar diverges to pass well backward, to reach the internal intermuscular septum above the internal condylar ridge, where it enters the posterior compartment of the arm. The *internal cutaneous* pierces the brachial fascia and passes forward just below the middle of the arm, and it lies between the brachial artery, to the outer side, and the basilic vein upon the inner, to be wholly superficial at the elbow. The *musculo-spiral nerve* lies for a very short distance behind the brachial artery upon the long head of the triceps before it is joined by the superior profunda branch and gains the musculo-spiral groove.

The artery gives off the superior profunda, the inferior profunda, the anastomotica magna, the nutrient, the muscular, and the terminals—the radial and ulnar arteries.

The *superior profunda artery* which lies first to the inner, then to the posterior side of the brachial, rises usually just below the teres major, perforates the septum, and then penetrates to the musculo-spiral groove, in which it runs for a certain distance. It gives off above, an ascending branch that supplies the triceps and forms an important anastomosis with the posterior circumflex. The cutaneous branches follow the nerve and supply the skin over the outer arm. The articular branch is given off behind the external intermuscular septum and runs downward in the substance of the triceps, anastomosing with the interosseous recurrent below, and, across the joint behind, immediately above the olecranon fossa, by an arch with the anastomotica magna. The terminal branch perforates the septum to become anterior at the elbow, and it anastomoses with the radial recurrent. It often gives off a nutrient artery or arteries to the upper end of the humerus, and it gives muscular branches to the triceps.

The *inferior profunda* usually rises from the inner side of the brachial about opposite the lower part of the coraco-brachialis insertion. It passes with the ulnar nerve through the internal intermuscular septum to back of the condyle, and there, under cover of the tendinous aponeurosis of the flexor carpi ulnaris, it anastomoses with the posterior ulnar recurrent and anastomotica magna. It supplies the humerus, triceps, and elbow joint, and it frequently gives off a branch that passes to the front of the joint and anastomoses with the anterior ulnar recurrent.

The *anastomotica magna* usually rises from the inner side of the brachial, a short distance above the bend of the elbow, runs downward and inward across the brachialis, and divides into an anterior and a posterior branch. The anterior branch anastomoses in front of the internal condyle, beneath the pronator teres, with the anterior ulnar recurrent. From this branch a branch often passes behind the condyle to anastomose with the posterior ulnar recurrent and the inferior profunda. The posterior branch perforates the internal septum, passes to the posterior surface of the internal condylar ridge, pierces the triceps, and there anastomoses with the articular branch of the superior profunda and with the interosseous recurrent.

The *nutrient* artery is given off variably from the brachial or one of its branches and passes through the nutrient foramen, downward toward the elbow. After entering the shaft of the bone, a branch passes upward toward the head and neck.

The *muscular branches*, from five to eight in number, are variably given off, from the outer side of the artery, to the coraco-brachialis, the biceps, and the brachialis muscles, usually at the points where the nerves enter these muscles.

The *musculo-cutaneous nerve*, arising from the outer cord of the brachial plexus, soon perforates the coraco-brachialis, and, still inclining outward, reaches the bend of the elbow and there piercing the fascia becomes superficial just at the outer border of the biceps tendon.

The Back of the Arm.—The *triceps* occupies the whole of the posterior compartment of the arm and is made up of three heads of origin. The long head rises by a flattened tendon from the upper part of the axillary border of the scapula and its adjacent lower glenoid rim. This tendon, with its muscle bundles, together with the outer (upper) humeral head, forms most of the superficial part of the muscle.

The inner head, rising below the musculo-spiral groove, is more deeply placed. The muscle bundles from these three heads converge below into a short common tendon which is inserted into the posterior part of the top of the olecranon process. A bursa underlies the tendon over the rest of the top of the process. The long head is joined upon its inner side by a slip of aponeurotic fascia derived from the lower border of the tendon of the latissimus. The outer, or upper, head occupies all the posterior and external surfaces of the humerus from the teres minor insertion to the groove. It also has fibres which are attached to the external intermuscular septum and the aponeurotic sheath bordering the groove. The groove is free. The inner, or lower, head rises from the posterior surface of the humerus below the groove and receives a narrow-pointed slip from high up near the insertion of the teres major, upon the inner side of the groove. It rises also from the whole length of the internal intermuscular septum and from a small part of the external intermuscular septum. The fibres of origin of the long and outer heads join and form a broad, flat tendon of insertion. A part of the fibres of this tendon are given off especially over the outer part of the elbow joint, and ultimately they expand so as to form a strong fascia that covers the forearm. The short fibres of the inner head are in great part inserted upon the deep surface of this tendon. A few fibres, however, are inserted directly upon the olecranon or into the posterior ligament of the elbow. The musculo-spiral nerve and the superior profunda artery supply muscular branches to each of the three heads.

The *musculo-spiral nerve* is the continuation of the posterior cord of the brachial plexus after there have been given off, in the axilla, the circumflex and the subscapulars. After passing for a short distance behind the lower part of the axillary artery and the upper part of the brachial artery, it dips backward, downward, and outward, from the position where it lies upon the lower part of the triceps, and then, after being joined by the superior profunda artery, it enters the musculo-spiral groove. It turns round behind the shaft of the humerus and appears at the outer side of the arm, where, at about four inches above the elbow joint, it pierces the external intermuscular septum and lies in the front compartment of the arm, deep between the brachialis on the inside and the brachio-radialis and the extensor carpi radialis longus upon the outside. In front of the external condyle of the humerus it divides into its terminal branches, the radial and the posterior interosseous. It gives off three cutaneous branches, and supplies muscular branches in the arm to the three heads of the triceps, the anconeus, the brachialis (in part), the brachio-radialis, and the extensor carpi radialis longus. The last three muscles are supplied

Arm and Forearm.

by branches given off in the front compartment. The *internal cutaneous branch* usually rises in the axilla in company with the branch which goes to the long head of the triceps, and then passes back of the arm. It supplies a middle dorsal strip of integument nearly as far down as to the elbow. The *upper external cutaneous branch* pierces the deep fascia in the line of the external intermuscular septum, at the upper third of the arm, accompanies the cephalic vein in the lower half of the arm, and supplies a strip of skin, from exit to elbow, on the antero-external surface of the arm. The *lower external cutaneous branch*, which is much larger, pierces the fascia somewhat lower down, and supplies the skin of the middle of the back of the forearm as far down as to the wrist. In its course it passes between the internal cutaneous nerve upon the inside and the musculo-spiral upon the outside.

The *lesser internal cutaneous nerve* (Wrisberg's) rises from the inner cord of the brachial plexus, passes as far down, in the front compartment, as to the inner side of the axillary vein, which latter separates it from the ulnar nerve, at the middle of the arm. At the elbow it turns backward to supply the skin over the olecranon.

The *internal cutaneous nerve* rises from the inner cord of the brachial plexus, and passes down the arm to the inner side of the brachial artery. With the basilic vein it perforates the deep fascia and supplies the skin of the upper and inner arm. Above the elbow the terminal branches, anterior and posterior, diverge slightly at the antero-internal side of the arm, to pass the elbow, where they supply the skin of the inner forearm, anteriorly and posteriorly, as far down as the wrist.

A terminal *branch* of the *musculo-cutaneous nerve* passes over the elbow and lies below in front of the radial artery. It supplies the outer side of the forearm, front and back.

Luzerne Coville.

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ARM AND FOREARM, DISEASES AND INJURIES OF THE.—In considering the diseases and injuries of the arm and forearm, I shall take up the different affections of the several structures under the following heads: I. Affections of the Skin; II. Affections of the Fascia; III. Affections of the Bones, the Periosteum, and the Joints; IV. Affections of the Muscles, Tendons, and Tendon Sheaths; V. Affections of the Blood-vessels; VI. Affections of the Lymphatic Vessels, Glands, and Bursæ; VII. Affections of the Nerves; VIII. Hysterical Lesions; IX. Tumors.

It will be my purpose to discuss more fully those affections of these different structures which show some peculiar manifestations when presenting themselves upon the upper extremities, and to deal with them less in detail when exhibiting upon the arm merely those features which are common to the same affections elsewhere in the body. Particularly in the case of diseases affecting the skin of the arm and forearm, not all the dermatic affections which may be found in this locality will be entitled to extensive consideration, but such forms of skin trouble only as are particularly prone to develop their lesions upon the arms. Furthermore, it will suffice with regard to most of these to call attention to the fact that certain lesions may be expected on the arms and forearms, and to describe their symptoms and appearance with sufficient accuracy to allow of their diagnosis, while more extended consideration of their pathology and treatment is to be sought under other headings in this work.

I. Affections of the Skin.

With regard to the diseases affecting the skin of the arms, we have to content ourselves for the most part with recording the observed fact of their appearance in this locality, owing to our ignorance of the causes that determine the outbreak of cutaneous lesions upon this part of the body.

It is necessary to bear in mind that the general principles of dermatology are applicable here as in other parts of the body, notably those which teach us that symmetrical lesions may generally be considered to be due to internal causes, while for unsymmetrical lesions there is *a priori* reason to think of local irritation as a cause of the affection. Similar weight should be given to considering the relation of the cutaneous lesion to the clothing of the part, inasmuch as certain lesions are prone to appear on unprotected parts, while others appear where the friction of the clothing, or vermin which the clothing may harbor, may give rise to local irritation. Other matters concerning the site of lesions of the skin on the arms, which may affect the diagnosis, are the lines of cleavage of the skin, and the presence of the lesions upon the flexor or upon the extensor surface of the affected limb, and finally the known course of certain of the brachial nerves and blood-vessels. Nor should the general rule of dermatological practice be forgotten which teaches us to compare the integument of the arms with that of the rest of the body and so gain an accurate knowledge of the anatomical distribution of the cutaneous lesions.

The more recent nosological systems of dermatology have sought to group the various lesions of the skin according to their pathological basis, and in the rapid review which I purpose to make of such cutaneous affections as have their common site upon the arms and forearms, I shall consider the different lesions in the general order of the classification of Jessner—to wit, functional disorders, circulatory disorders, and inflammations, superficial and deep-seated; finally, I shall consider briefly traumatisms of the skin.

(*a*) *Functional Disorders of the Skin.*—Of the first class, that of functional disorders of the skin, such as pruritus, hyperidrosis, seborrhœa, it will suffice to say that none of them have any predilection for the arms or forearms which would justify their consideration here, if we except the entirely unimportant erythema solare which is frequently seen on the arms of farmers, bathers, and laborers who work in the open air with the sleeves rolled up.

(*b*) *Circulatory Disorders of the Skin.*—Of the diseases of the skin classified by Jessner as circulatory disorders, the lesions of purpura and scurvy, while undoubtedly they show themselves with comparative frequency on the arms, yet it is rare that they should show themselves there with any special preponderance of distribution over other parts of the body. Peliosis rheumatica, however, is a purpuric affection whose predilection for the arms merits our attention in considering the cutaneous affections of these members.

In Peliosis rheumatica, also called purpura rheumatica, a period of invasion precedes the eruption for a variable length of time, and is shown by general malaise, systemic disturbances, and painful swelling of the joints, especially of the knees, wrists, and ankles. The temperature may be normal, but more often it rises to 100° F. or more. In a few days the eruption appears and the pain then subsides. The lesions occupy practically the same regions as do those of erythema multiforme (*vide infra*), namely, the wrists, forearms, and lower legs, but sometimes they are particularly located about and around the inflamed joints. Some authorities indeed classify the affection as a variety of erythema multiforme. The lesions consist of bluish-red patches, and slightly elevated, bright-red papules which quickly become purplish; they may, however, be purpuric from the first. Their color cannot be effaced by pressure. After persisting for a few days, they pass through the various gradations of color seen in a contusion and disappear altogether. The disease may be limited to one outbreak, or the eruption may come out in several crops and run a course of from four to six weeks, or it may disappear altogether and ten days or more later a relapse occur, and the joint and other symptoms again become manifest. The recognition of hemorrhage into the skin is easy when it is borne in mind that pressure does not cause the redness to fade. Such lesions occupying the localities mentioned, and associated with the

cles perhaps one-third of an inch in size (erythema tuberculatum). The centres then begin to flatten and fade out and assume a characteristic bluish-red hue (erythema annulare). At the periphery where the eruption is extending, the lesions preserve their elevated form and reddish tint. Adjacent patches may coalesce and form irregular figures, known as erythema gyratum and erythema figuratum. More rarely the appearance of blebs gives us the form known as erythema bullosum. Herpes iris is the designation given to a vesicular form of this erythema in which new concentric rings of papulo-vesicles appear in the depressed purplish centre of an annular erythema. These various forms, often looked upon as distinct diseases, are in reality merely stages of the same process with varying amounts of exudation. A case may go through several of them and even show them simultaneously, for multiformity is characteristic of the disease; but usually one type only is present, and the commonest by far is the papular one. The malady occurs especially in the spring and fall, and lasts for from four to six weeks. It happens at any age, and is somewhat more frequent in females than in males. The mucosæ are occasionally affected. It is prone to relapse, and usually reappears in its original type. It is occasionally complicated with purpura, acute articular rheumatism, and endocarditis.

Its typical course and location, the papules or tubercles whose red color is removable on pressure, and the absence of desquamation are sufficient to characterize the disease. An *eczema* has exudations, scales, and crusts, and itches intensely. *Urticaria* has papules or pinkish, fugacious elevations, with much itching and reflex irritability of the skin. A *papular syphiloderm* is copper colored and not removable by pressure; the palms and soles are usually involved, and other syphilitic symptoms are generally present. *Prurigo* has deep seated, colorless papules, begins in childhood, and itches intensely. *Tricophytosis corporis* is scaly in the centre, and the parasite can usually be readily found.

While the arms are one of the rarer sites for the vesicular eruption of HERPES ZOSTER, yet the fact should be borne in mind that this disease occasionally manifests itself in the course of the brachial nerves. Its characteristic symptoms should make the diagnosis in most cases easy. Its symptomatology is this: The eruption is almost regularly preceded by distinct premonitory symptoms, consisting mainly in neuralgic pains of variable degrees of severity over the area about to be affected and lasting from a few hours to several days, occasionally even for weeks. Sometimes they are missing entirely, particularly in young children. The pain may be of a diffuse character, or, again, confined to certain points which correspond anatomically to the underlying nerves and their ramifications. The cutaneous phenomena make their appearance always in an acute manner At first there are redness and slight swelling over the diseased area. This is soon followed by groups of small papular elevations, which in the course of a few hours are transformed into vesicles from the size of a pin-head to that of a small split pea, closely clustered together, fully distended, and filled with a clear serous fluid. The vesicles are at first sharply contoured and surrounded by an erythematous halo. Further on they may, by peripheral extension, become confluent so as to form larger bullæ. They have generally little tendency to burst, and do so only accidentally. Occasionally a larger surface may be uniformly studded with these vesicles, but as a rule there are several distinct and isolated groups of them, varying in size from a dime to the palm of the hand, of irregular shape, and arranged more or less exactly in the form of a semigirdle when situated on the trunk. In other regions the unilateral distribution of the eruption along the course of one or several cutaneous nerves forms a striking feature. These groups come out successively, the one nearest the spinal column usually appearing first, but all the vesicles constituting one patch are formed and run their course contemporaneously. Their contents remain clear for three or four days, then become gradually more turbid, puriform, and by and by dry out, forming brownish crusts which finally fall off and leave in their place reddish or bluish discolorations. These persist for some time and gradually fade away. In some instances, however, permanent marks may remain, which, by their arrangement and distribution, are quite characteristic of the preceding eruption. The time consumed for the completion of the cycle in each individual group is from eight to ten days, but through the successive appearance of fresh crops of vesicles when the older ones have almost reached the point of involution, the whole process may last up to four or even six weeks.

The subjective symptoms which accompany the eruption are very variable. While in some cases the preliminary neuralgia ceases with the advent of the cutaneous manifestations, it is more often present during the whole duration of the disease, and is intensified by a burning and smarting sensation with which every new crop of lesions is ushered in. Some patients complain very little, others seem to suffer very much, particularly from nightly exacerbations which may disturb the sleep. Even after the completion of the eruptive stage there may remain for some weeks, and occasionally for a long period, disturbances in the sensory functions of the affected area. Fever is frequently present with the zoster, but is rarely of much consequence. A very remarkable fact in regard to zoster is that it attacks a person only once during a lifetime. Exceptions to this are so few and far between that they do not materially affect the generally accepted law.

The termination of the local manifestations does not always indicate a complete restoration in the affected territory. Not only may neuralgic pains persist for some time and become the source of agonizing attacks which deteriorate the patient's health, but in some cases there remain pruritus, hyperæsthesia, or complete anæsthesia and analgesia. Of particular interest is the so-called "anæsthesia dolorosa," which occasionally follows a zoster. An explanation for this peculiar phenomenon may be found in that the pathological changes in the course of the nerve disturb the transmission of sensation from the surface to the centre, whereby the anæsthesia is produced, while the cause of the pain is located in the sensory root of the spinal column.

Although zoster is generally attributed to disturbances in the sensory nerves, the strange fact must be recorded that often muscular atrophy and motor paralysis are caused by it. Paralysis of the arm muscles after zoster brachialis was noted by Schwimmer, Joffroy, Broadbent, and Gibney.

The characteristics of zoster are usually so marked that little difficulty can exist in recognizing it. Its unilateral distribution along the course of well-known cutaneous nerves, the successive appearance of groups of vesicles, their cyclic course, and the concomitant neuralgia will easily establish the diagnosis. From eczema it is readily differentiated by the larger size of its vesicles and their tendency to persist as such, whereas in the former they burst very soon and give rise to characteristic oozing (Zeissler).

PSORIASIS is a disease which on account of its customary distribution merits a description among the cutaneous affections of the arm. The lesions of psoriasis are characterized by the formation of a thick imbricated covering of dry scales of a light yellow, pearly white, or silvery color situated on a reddish, slightly elevated, well-defined base. The disease appears without premonitory symptoms, and the first indication of its presence is the appearance of small pin-head sized, rose-colored spots, which in a day or two become covered with silvery scales, psoriasis punctata. These spots increase at the periphery, while the scales become piled up into thick crusts which, from their resemblance to drops of mortar spattered on the skin, constitute the form known as psoriasis guttata. If the attack runs an acute course, the patches rapidly increase in size, and in a week may attain the dimensions of coins, psoriasis nummularis. Generally, however, the eruption is noted for its chronicity, and months are re-

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munity to the attack of the streptococcus. This will account for the tendency that is sometimes manifested in streptococcic processes to linger on in a mitigated yet protracted manner, continuing to vegetate in the tissues in an obstinate yet less virulent form than at the outset of the attack. This is particularly prone to be the case in cases of extensive involvement of tissues of low vascularity. The vitality of the germs permits their continuous growth in tissues of feeble resisting-powers, while the system, through the accumulated stores of antitoxin, can so far neutralize the toxic products of the bacterial growth that the materials absorbed do not poison the body, as is shown by the diminished fever and the general subsidence of general constitutional symptoms, in spite of the lingering of the local process in the fascial layers. Thus arises a prolonged, quasi-chronic form of the trouble, which is particularly likely to supervene when the fascial planes of the extremities are invaded. The streptococcic invasion of the fascial planes of the arm and forearm is generally first along the deep fascia, with or without concomitant involvement of the superficial fascia and the skin. Only when the process has been for some time under way do the muscular septa become involved, and then a most formidable condition known as a deep dissecting phlegmon results.

The systemic effects have already been mentioned above. The local symptoms are characteristic in typical cases, and allow a ready diagnosis. At a point, it may be bordering on a wound, but more frequently at a greater or less distance to the proximal side of it, the skin will be seen to have a somewhat livid hue, and will appear somewhat œdematous; yet there will be lacking the dense infiltration of all the tissue layers which characterizes a general cellulitis depending upon infection with the staphylococcus. Then, too, the classical signs of inflammatory action will be less marked, unless the skin and superficial fascia are also involved—*i.e.*, there will be, as compared with the staphylococcic infection, less redness, less swelling, less heat, and less pain. The original wound may or may not appear to be involved in the infection, or if the wound is itself the seat of suppuration, the channel of communication between the original wound and the seat of the secondary suppurative process may be difficult to trace.

The limit of the involved area is very indistinct, as, owing to the want of vascularity of the affected tissues, there is no marked inflammatory induration acting as a wall of circumvallation about the focus of infection. To the examining finger, the sensation imparted on palpation is rather that of a layer of fluid separating the tissues, than that of a localized abscess with indurated borders and softening centre.

When the skin and superficial fascia are also involved, which is the exception rather than the rule, the implication of these more vascular structures in the morbid process will lend the appearance of a more acutely inflammatory type to the disease. The redness will be that of the angry blush of cutaneous erysipelas. The inflammatory exudation into the interstices of the skin will afford a more marked swelling, and a brawny feel to the tissues on palpation. The epidermis may be lifted in more or less extensive vesicles or blebs, whose original serous contents may become sanguinolent, and the delimitation of the focus of infection may be more distinct, the deep fascia being rarely involved in these cases much beyond the cutaneous blush.

The disease, if untreated or if refractory to treatment, though it tends to recovery through exhaustion of the virulence of the infecting germ, yet is likely to be extremely destructive to the tissues which it attacks; and if the accumulating pus is not freely evacuated, the process, although residing by preference in the layers of connective tissue first attacked, yet can easily transgress these limits and by the erosive and solvent action of the pus, or by the progressive outgrowth of the streptococci, involve contiguous structures to an extent that may be dangerous to life through secondary hemorrhage, due to erosion of an artery, or from pyæmia, due to septic thrombosis in the veins followed by "yellow softening" of the clot and embolism.

The prognosis, in the forms affecting the fascia alone, is good, if opportunity is given for a free hand in the surgical treatment of the case, and the patient has a certain strength of constitution behind him. In the form more strictly known as phlegmonous erysipelas—*i.e.*, the form complicated by the involvement of the skin and superficial fascia as well—the prognosis is grave if any considerable portion of the limb is involved. In that form of the disease in which the deeper connective-tissue planes are involved—*i.e.*, the intramuscular septa and the perimysium—while the prognosis as to life is fair, the prognosis as to restoration of the limb, or even as to life without sacrificing the limb, is uncertain.

The diagnosis of typical cases is not difficult, the non-involvement of the adjoining structures being more or less readily appreciable and characteristic. Erysipelatous infection of the fascia is to be differentiated from the general inflammatory œdema surrounding a focus of deep-seated suppuration, from malignant œdema, and from the tuberculous and syphilitic forms of connective-tissue disease. The points of differentiation from deep-seated and destructive abscess of staphylococcic origin have been described above. They are: non-involvement of the skin, or its involvement under a strictly erysipelatous type of inflammation with the characteristic blush; the formation of blebs and superficial infiltration and thickening of the skin itself, quite different from the brawniness accompanying the infiltration of the deeper layers, which is characteristic of a deep abscess. Furthermore, there is wanting in this form of inflammation the delimiting wall of inflammatory exudate which marks ordinary abscess formation, and no distinct line of demarcation separates the affected from the healthy tissue.

From malignant œdema an erysipelatous infection of the fascial planes is likewise to be differentiated by the less malignant and acute character of the disease; by the absence of the extreme fetor accompanying that lesion, and by its tendency to confine itself to one kind or to one layer of tissue. Malignant œdema is a rare disease in man, and, according to Park, is essentially a specific form of gangrene.

From the tuberculous form of the disease, the erysipelatous form is to be distinguished by its rather prompt following upon a wound on the distal side of the phlegmon (two to twelve days), by its rather rapid rise to an acme (four to six days), by distinct evidences of sepsis rather than cachexia, by the character of the evacuated discharge (more distinctly purulent and often containing more or less extensive sloughs), and by the pain and heat, which are much more distinct than in the cold abscess.

From syphilis of the fascia, an erysipelatous process can be distinguished by the absence of the gummatous infiltration, by the fever and pain, by the sudden onset often consecutive to a lesion on the distal side of the phlegmon, and by the absence of other manifestations of syphilis. It must, however, be borne in mind that a syphilitic subject may, quite as readily as any other, become the subject likewise of a non-syphilitic infection of the fascia.

The treatment of erysipelatous disease of the fascia consists in giving the freest possible vent to the pus, in vigorous local antisepsis, in stimulating and supporting the general system, and in some instances in the introduction into the circulation of a specific antitoxin.

As long as the disease is confined to the deep fascia, we may expect by free incision and by the local application of antiseptics to arrest the infectious process. Incisions to this end should be made subject to these rules: They should be parallel to the long axis of the limb; they should penetrate down to, but not beyond, the deep fascia; and they should be numerous enough and long enough to give easy access to all demonstrably affected tissue. With these rules in mind the surgeon should and may incise the tissues freely and extensively, and may do so without great danger either of provoking extensive hemorrhage or of exposing the patient to sloughing of

the skin, or to more extensive gangrene of the extremities, as the main blood-vessels run beneath the deep fascia, and the cutaneous branches are fully as likely to have been already obliterated by the septic process as they are to be divided by the knife. It is well to avoid the large superficial venous trunks of the forearm, and particular pains should be taken to avoid the mediana profunda vein at the angle of divergence of the median basilic and median cephalic veins, as this is the main communicating branch between the deep and superficial sets of blood-vessels, and by extension along this vein a thrombus might communicate the septic process to the deeper tissues.

After free incisions have been made, there comes up the question of whether or not it is best to use the curette. This is generally pretty decidedly to be answered in the negative. The introduction of the curette, even of the rinsing curette, into the crevices between the deep fascia and the skin, where the infectious process is mainly located, can hardly serve to dislodge septic material spread over a large area to any such degree of thoroughness as will compensate for the disadvantages attending the mechanical lifting of one anatomical layer off the other, for by means of this disturbance of the anatomical layers the infecting germs are given more ready access to still uninvaded regions. The case is quite different from that of a circumscribed abscess, where over a region of comparative small area necrotic tissue needs to be removed to a considerable depth. In fascial erysipelas a large area is affected to only a moderate depth; and weighing the results of the unavoidable trauma on the one hand inflicted by the instrument, with the proportionate gain in the removal of septic material on the other hand, the balance will in most cases be against the use of the curette in septic fascial disease.

Less damage is likely to ensue from the careful use of the probe in exploring the extent to which the purulent process may have undermined the skin; in fact, a careful exploration of this kind is indispensable to guide the surgeon in making his incisions. It is particularly necessary to make at least one incision at the proximal border of the suppurating area, so as to permit thorough flushing of the infected tract and to establish through-and-through drainage, and the upper limits of the suppuration can most conveniently be determined by the use of the probe.

When once the limits of the disease have been determined and the necessary incisions have been made, a thorough flushing of the diseased area with antiseptic solutions should follow. To this end considerable hydrostatic pressure should be employed, and every effort should be made to force the fluid injected at one incision to escape at another. If this does not readily follow on introducing the tip of the irrigating-tube at one orifice, it is quite in order to make a passage for the fluid by subcutaneous dissection if necessary, either by dividing the obstructing tissue bands with the knife, or by forcing the tip of the glass irrigating-tube under the skin until the flow is established from one incision to another. A solution of mercuric chloride, 1 to 1,000, is frequently used for this purpose, and should be passed through the wounds in large quantities. Stronger solutions of this same salt may be used; but if they are, a second flushing with plain water should follow on account of the poisonous qualities of the salt.

Aside from its value as an antiseptic, certain mechanical advantages attend the use of hydrogen peroxide in septic infection of the fascial planes—namely, the liberated gas lifts apart the layers of tissue and opens up the diseased territory to the further action of the antiseptic, yet lifts the superficial layer very gently and evenly without carrying septic material into uninvaded areas. Furthermore, the development of the oxygen gas can be felt through the integument, and the bubbling of the gas may be sufficiently appreciable to the touch of the surgeon to act as an indicator of the presence of suppurating tracts, perhaps unsuspected from investigation with the probe alone.

After free multiple incisions and thorough flushing, seton drains should be inserted, passing subcutaneously from one incision to another; this is a far more useful form of drainage than the mere packing of the wound with gauze. In fact, distention of the pockets is to be avoided on account of the undesirable tension on the margins of the affected area where the process is likely to extend. It is essential to the usefulness of the seton that the incision through which it enters and that through which it emerges should be sufficiently ample so that the lips of the wound shall not hug tightly the material of which the seton is composed, otherwise the object both of the seton and of the incision is nullified. The object of the seton is strictly that of a wick, and this function is much better fulfilled by a slender seton, easily movable to and fro in its bed, than by a large mass of material which chokes the orifices of entrance and of exit and distends the cavity which it meant to drain. The best material for a seton is sterilized absorbent lamp-wicking, or perhaps iodoform lamp-wicking. A good substitute for this is a ribbon of plain or iodoform gauze, from one-half to one and a half inches wide, folded once or twice on itself. Either the seton should be threaded through the eye of a seton probe, or through the eye of the probe should be threaded a ligature of heavy silk and this loop be used as the carrier for the bulkier seton.

After the incisions are made and the wound is flushed out, and the setons are drawn through, the question of dressings comes up.

Just here it is necessary to suggest caution in the indiscriminate application of wet dressings. The advantages in the use of wet dressings lie in the greater absorptive powers of the wet dressing by which the discharges are more readily withdrawn from the neighborhood of the wounds, and in the more efficient action of the antiseptics with which the dressings may be permeated.

The dangers from wet dressings, however, are also twofold. First, they provoke a certain amount of maceration of the skin, by which erysipelatous dermatitis, an ever-threatening complication, is invited. Secondly, the relaxation and softening of the tissues, which is advantageous in relieving the stasis in the capillaries where more vascular structures are involved, may prove equally effective in furthering the spread of the streptococci along the planes of soft and comparatively non-vascular tissue which are involved in fascial phlegmons, allowing the process to extend in tracts which might otherwise be less vulnerable to their attack.

In view of these two objections, I am convinced that wet dressings must be used with considerable caution in phlegmons whose principal seat is between the deep fascia and the skin, to avoid encouraging the extension rather than the arrest of the disease. The more free and complete the drainage, however, the less these objections hold, and where the incisions are ample and numerous, the obvious advantages of the wet dressings may more than counterbalance the objections to them, to which attention has been called by way of caution.

In any case the need of frequent renewal of the dressings is imperative. When it is impossible, through too great fatigue and pain to the patient, to redress the wound sufficiently often to make headway against the persistent suppuration, with the proviso that the incisions shall be sufficient in number and in extent, the constant drip or the constant bath may advantageously be substituted for the wet dressing. Inasmuch, however, as the disease we are now considering affects principally non-vascular tissues, the great benefits which follow this form of treatment when another class of tissues is involved, are not so conspicuous in cases of purely fascial disease. In cases complicated by cutaneous erysipelas, the constant bath, however, will be found of great value.

At subsequent dressings, after abundant provision has been made for the speedy discharge of pus, great advantage will be found in saturating the wicks which are drawn beneath the skin from incision to incision with Peruvian balsam, ichthyol, or some other tissue stimulant, and this

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the fascia is almost always of one type—that of a gum matous deposit. This type of syphilitic lesion is one of the later manifestations of syphilis, and, except in the precocious or malignant type of the disease, is scarcely to be looked for until after the second year. A painless, though possibly tender subcutaneous tumor extending rather widely beneath the skin, without the characteristics of malignancy on the one hand, nor the encapsulation and lobulation of the lipoma or soft fibroma on the other hand, nor yet the fluidity of an advanced tuberculous or pyogenic process, will suggest the diagnosis of fascial gumma. When the gummy deposits have likewise invaded the skin proper, and secondary infection with pus germs has taken place, the differentiation between syphilis and tuberculosis of the fascia may be somewhat ambiguous. Incision into the mass will soon reveal the characteristic appearance of the gumma if the diagnosis be not already made. If still not made at the time of the incision, the exceedingly intractable character of the lesion under ordinary surgical treatment will suggest the diagnosis, especially when contrasted with its readiness to heal under antiseptic treatment when this is combined with the exhibition of antisyphilitics.

It has been well said that the whole responsibility of the surgeon is not discharged when a diagnosis of syphilis has been made, and gumma of the antibrachial fascia is eminently a case in point. Although by stimulating the activity of the lymphatics with potassium iodide, even an extensive gummatous deposit may be eventually removed, yet the complete and speedy restoration of the arm is much better insured, especially when secondary pyogenic infection is present, by free incision and vigorous clearing away of the gumma with the rinsing curette, depending on the constitutional treatment to complete the cure.

(*d*) *Contracture of the Antibrachial Fascia.*—To the diseases of the fascia which have thus far been described must be added, for the sake of completeness, certain rare cases of contracture of the antibrachial fascia in which this membrane impedes the action of the muscles governing the hand by rendering the member as it were "hidebound." Little or nothing is known of the pathology of this rare condition, except that it is sometimes seen as the sequel, either temporary or permanent, of other forms of fascial disease. The affection is sometimes seen, however, in a strictly progressive form without traceable antecedent disease or injury.

Steaming and massage would suggest themselves as the most promising means at hand for combating the difficulty, and A. Richet has recorded one case which yielded to potassium iodide, and was in consequence deemed to be of syphilitic origin.

III. Affections of the Bones, the Periosteum, and the Joints.

(*a*) *The Bones.*—Of the bones of the arm and forearm, the ulna or radius may be CONGENITALLY ABSENT; in which case the remaining bone undergoes a compensatory hypertrophy, and this produces a lateral curvature of the wrist away from the enlarged side.

The bones may ATROPHY as a senile change or from disuse, especially in long-standing ankylosis, unreduced dislocation, or paralysis, or their development may be arrested in the later stages of infantile paralysis.

In ACHONDROPLASIA the bones of the forearm often appear much thickened and curved.

RICKETS, as Park describes it, is a constitutional dystrophy caused by improper deposition of calcareous material in the soft and somewhat perverted fœtal cartilages. Pathologically it is marked both by a defect in the calcium content and also by the irregular epiphyseal lines and excessive amount of vascular tissue. "On making a section through the end of the bone, one sees that instead of the two sides of the epiphyseal cartilage being parallel to each other, that next the diaphysis is quite irregular, there are islets of cartilage extending into the bone, the epiphyseal line is very much thickened and the ossification is very irregular" (Cheyne). The result is that at the epiphyseal lines one can feel a distinct enlargement, especially noticeable at the wrist, the lower end of the radius being as a rule the first part affected. Owing to the softening of the bony tissue, curves and deviations of the bones of the arms occur in severe cases in infancy, secondary to kyphosis of the spinal column, the child tending to assume a frog like position to relieve the spine of the weight of his head and shoulders. In some instances fractures have been observed to occur in rickety bones on slight provocation. The treatment is regulation of the diet and improvement in the hygienic conditions together with the administration of tonics. Phosphorus and the hypophosphites are especially recommended.

The radius is a common place for the commencement of OSTEITIS DEFORMANS. Here the bones enlarge and soften, and a distinct bowing is at times noticed, while from the irregular enlargement of the articular ends, the hand is often deflected. This disease, which is also known as Paget's disease of the bones, is a rare affection, appearing generally after middle age. The disease is essentially a symmetrical one

The articular ends of the humerus and ulna may be involved in the hypertrophy characteristic of MARIE'S DISEASE or *ostéoarthropathie hypertrophiante pneumique.*

In senile atrophy, osteomalacia and osteopsathyrosis, as also in rickets, in syringomyelia, and in metastatic deposits from malignant tumors, *e.g.*, carcinoma of the breast, SPONTANEOUS OR PATHOLOGICAL FRACTURES are prone to occur due to the diminished resisting-power of the bony tissue. Slight falls, as from a chair, or even moderately severe muscular strain may be sufficient to cause these injuries, and when once incurred they often refuse to unite properly.

Of the rarer forms of inflammatory disease of the osseous system occurring in the upper extremities, ACTINOMYCOSIS occurs as a secondary deposit. LEPROSY may attack the bones directly or their nutrition may be interfered with through the influence of this disease upon their trophic nerves. HYDATID CYSTS may also develop in the bones, leading to spontaneous fracture or to circumscribed swellings. In SCURVY, hemorrhage, either of a subperiosteal nature or directly into the epiphyseal cartilage, may take place in the bones of the arm, especially at the distal extremity of the radius, giving rise to some swelling and much tenderness over the point affected. Separation of the epiphysis is apt to follow.

TUBERCULOSIS of the bones of the arm may take place in the acute miliary form, which is as rapid in its ravages in this tissue as elsewhere. This form is fortunately rare, and its symptoms and treatment are those of acute osteomyelitis. The chronic form of bone tuberculosis is quite common, and most often occurs near the epiphyseal lines due to the plugging of the terminal arteries (Warren). From this the disease spreads by the formation of granulation tissue with a tendency to sclerosis and thickening of the periosteum. So long as the disease is active, the tubercles tend to spread, and following the direction of least resistance, the shaft, the periosteum (with sinus formation), or the joints may be invaded. This tendency to invasion of the joints is characteristic of tuberculous disease, and usually occurs, as above stated, by direct extension from a focus in the bone. It leads to destruction of the joint structures, and is accompanied by tuberculous or inflammatory infiltration of the neighboring parts. Deformity of the bone from inflammatory thickening with some local tenderness will indicate chronic bone tuberculosis. The amount of pain, as long as the joint is not involved, may be slight. A characteristic afternoon rise of temperature will serve to differentiate tuberculosis of the bone from gumma and from osteosarcoma.

The treatment of bone tuberculosis is both constitutional and local. The former aims to maintain the best possible hygiene and to build up the debilitated system by tonics. The local treatment consists in immobilizing the part by proper orthopædic appliances, by the injection directly into the affected area of antituberculous sub-

stances, notably a ten-per-cent. emulsion of iodoform, the balsam of Peru, or a one-per-cent. solution of the trichloride of iodine as recommended by Senn. Ignipuncture is another measure which has been applied in the local treatment of tuberculous bone lesions. The point of a Paquelin cautery at a white heat is thrust deep into the affected area. The channel thus made is then dressed with iodoform. The local treatment may also include operative measures by which the tuberculous focus may be removed with a sharp spoon and the part put up in an antiseptic dressing and a fixation splint.

If the joint is extensively involved, its resection may be necessary, while in the miliary form of the disease, or when a condition has been reached in which resection will no longer eradicate the affection, amputation of the limb may be required.

SYPHILIS in its later stages may attack the bones of the arm, involving first the periosteum and leading to the formation of granulation tissue that tends to become ossified, or to the growth of true gumma which tends to break down. When the bone itself is invaded, which is rare in this locality, either a gumma or granulation tissue is formed with a general tendency toward ossification.

The differentiation between syphilis and tuberculosis of the bones may be made clear by observing the following points. In syphilis we have a history of chancre and skin lesions. The disease usually attacks the periosteum. It does not tend to invade the joint; does not tend to suppurate or break down; the pain is usually nocturnal, and is referred at first to the points of attachment of the ligaments, and then to exposed portions of the bone. These symptoms yield to the exhibition of mercury and iodide of potassium.

Tuberculosis, on the other hand, may be secondary to tuberculous disease elsewhere; it first attacks the medulla and as a rule tends to invade the joints. The tuberculous deposit softens and liquefies. There is not much pain except on motion. The symptoms do not yield to the exhibition of antiluetic remedies. There is a characteristic pyrexia.

The treatment of bone syphilis is first the administration of the usual antisyphilitic remedies. Should secondary local pyogenic infection have occurred, it is proper to cut down upon the part and thoroughly curette.

ACUTE OSTEOMYELITIS is an inflammatory disease of the marrow of the bone terminating in suppuration. As a primary disease it is most common in children. It is prone to occur after slight traumatisms followed by injudicious exposure to the weather or other depressing influences, particularly when furuncles or other pyogenic processes are active in other parts of the body. Thus it is seen after slight accidents in bathers, skaters, where sitting on the ground, or exposure to the weather when incompletely clad, allows the vital forces to become depressed. It may, of course, follow upon more extensive wounds, especially upon compound fractures, where direct access to the medullary canal is afforded to the infecting germ. It frequently follows as a sequel to acute exhausting disease—typhoid fever, scarlet fever, etc. It is essentially a phlegmonous inflammation of the marrow. The osteal and periosteal veins are closed by septic thrombi, and true pyemia may result from their liquefaction and the discharge of septic matter into the circulation. The medullary canal becomes filled with sanguineous pus that permeates the bone from within. On reaching the periosteum, it burrows beneath it denuding the bone. After a longer or shorter period of restraint, due to resistance of this membrane, it breaks through it, and, if the septic processes have not already destroyed life, sinus formation occurs with profuse and obstinate discharge of pus. Owing to the interruption of its nutrient supply, more or less extensive necrosis of the bone generally occurs, and sequestra are formed varying in size from that of a pin-head to those involving almost the whole bone.

The disease, as a rule, is ushered in by a chill and other symptoms of an acute febrile infection. The local symptoms are an intense pain of a diffuse, boring character and tenderness over the portion where the disease is nearest the surface. Marked swelling and redness occur only when the inflammation has spread to the soft parts. The interference with function is most pronounced. Characteristic of this disease is the intense pain which is caused by tapping or lightly jarring the bone. By careful manipulation it is usually possible to exclude disease in the adjacent joints.

If left to itself, the disease is marked by most intense pain until the moment when the restraining periosteum gives way, yielding an avenue for the escape of the confined pus into the surrounding soft parts. With the eruption of the pus through the periosteum, the classical signs of inflammation, heat, redness, and swelling become much more marked. A secondary œdema, however, accompanied with a more or less distinct marbleization of the superficial veins, is often evident for some time before the perforation of the periosteum occurs. High fever, delirium, and all the symptoms of most severe sepsis attend the disease from its outset. Spontaneous fracture, suppuration of the epiphysis, purulent synovitis, thrombosis, and metastatic infections occur as complications.

Rest and elevation with the use of the ice-bag, or continued fomentation may be of service in arresting the disease in its earliest stages. In no disease, however, is prompt and decisive surgical intervention more urgently demanded than in osteomyelitis. When, after brief trial of these agents, decided subsidence of the symptoms is not induced, the only way of limiting the ravages of the infective process is by cutting down upon and drilling into or otherwise opening the medullary canal; nor should the involvement of the adjacent soft parts be awaited before proceeding to these radical measures. The point of greatest tenderness will indicate the most favorable site for incision, and it is quite possible that when through early and free incision relief is afforded to the intense congestion of the surrounding parts, actual suppuration of the bone may be averted. To this end the incision must extend not only down to the periosteum, but actually to the bone itself, and no damage will be done and great relief may be afforded by piercing the compact layer of the bone in one or several places either with a bone drill or with a small trephine. If through the apertures thus made into the bone pus be discovered in the medullary canal, it will be necessary in almost all instances to open the canal with a chisel throughout the greater part of its length, and with a sharp spoon to remove very thoroughly its infected contents. The wound should then be packed, and under the use of frequent dressings and copious irrigation, we may in most instances hope for the arrest of the disease without too extensive necrosis of the bone.

Under any other form of treatment the destruction of the bone throughout the greater portion of its length is almost certain, and withal the danger to life itself from acute osteomyelitis is very great; so that extensive as may seem the operative measures taken for the relief of the condition, they are really to the last degree conservative. It is astonishing to what extent, particularly in children in whom the periosteum has survived the suppurative process, the shaft of the long bones will be reproduced.

When extensive portions of one of the bones of the forearm have been removed, either by disease or by operative measures, it is necessary to take great pains during the process of repair and reconstruction of the tissues, to maintain the mechanical support which was afforded to the forearm by the defective bone, as the atrophy consequent upon osteomyelitis of the ulna, unless proper splints be provided, will cause great deflection of the hand toward the affected side. Still more markedly is this the case when, through similar disease of the radius, the integrity of the shaft of that bone has been compromised.

The FRACTURES which occur in the arm and forearm are fully treated of elsewhere, but certain facts in connection with them deserve mention here. The tip of the olec-

ranon process when fractured behaves in a manner similar to the patella. On account of the action of the triceps muscle there is more or less diastasis of the fragments, precluding the development of crepitation and interfering with bony union. The treatment is on lines analogous to that pursued in fractures of the patella, and the surgeon is called upon to decide as to the advisability of incision for the purpose of wiring the fragments together.

The multiplicity of the muscles attached to the various bones of the arm causes many deformities in the limb after fracture of the bones. If the tendency to these deformities is not foreseen and adequately provided against when the fracture is recent, the fragments may unite at such an angle as to impede considerably the function of the limb. This is particularly the case in fractures above the elbow joint, and especially in fractures of the condyles and in separation of the lower epiphysis of the humerus. To obviate this accident it is often necessary to wire the separated processes to the shaft of the bone and to each other. Exuberant callus produced during the healing of a fracture may seriously impede any or all of the functions of the elbow joint, and synostosis between the radius and ulna may occur to such an extent as entirely to destroy the functions of pronation and supination. Exuberant callus may also include the nerves and vessels of the arm so as seriously to compromise their functions.

(*b*) *The Periosteum.*—The bones of the arm and forearm are also, in common with the other bones of the body, frequently the seat of disease affecting primarily and sometimes exclusively the periosteum; often of traumatic origin, but sometimes due undoubtedly to rheumatism (met with particularly about the point of tendon insertions), and not infrequently to direct or indirect pyogenic infection, or to syphilis. When pyogenic infection has taken place, the differential diagnosis between the periosteal and endosteal form of the disease will be suggested by the lessened gravity of the symptoms, by the absence of marked evidences of general sepsis, together with the presence of similar local signs. In the absence of pronounced suppuration, we are justified in pursuing longer, in this form of bone disease than in the other, our efforts to check the process by means of rest, counter-irritation, fomentations, etc., but with the advent of signs pointing to pus formation, free incision and drainage are as positively indicated as before.

(*c*) *The Joints.*—The articulations of the upper extremities are, like those elsewhere in the body, liable to dislocation; for discussions of which other portions of this work may be consulted. It will, however, be well to call attention here to a somewhat rare affection of the elbow, occurring exclusively in infants and young children, resulting from forcible dragging on the forearm, often by the nurse, or in play. In this condition the forearm is held flexed in a prone or semi-prone position, and supination is very painful. The condition is probably one of subluxation of the radius downward, and the partial escape of its head from the grasp of the orbicular ligament; the normal laxity of the ligaments in childhood and the want of full development of the head of the radius contributing to make the condition possible. The signs may be removed by complete supination followed by flexion, under an anæsthetic if necessary. The forearm should then be placed in a sling and massage and careful exercise employed.

Of the primary inflammations in these joints, SIMPLE SYNOVITIS is perhaps the most common. The acute form may be due to trauma or to over-use, and gives rise to pain on pressure or on movement of the joint, and to swelling due to an increase in the amount of synovial fluid, sometimes to an effusion of blood. A bulging tumor is formed where the joint capsule is thin; in the elbow joint the tumor is generally shown posteriorly. Purulent infection of the effusion may take place.

The treatment of simple synovitis is rest, pressure, cold or heat; in obstinate or unmanageable cases, incision and irrigation of the joint may be called for.

The chronic form of synovitis may date from a previous acute attack, or may be chronic from the start. The pain in this form is either small or absent. Fluctuation can usually be elicited, while creaking on moving the joint may be quite a noticeable symptom. The treatment here, too, will consist in pressure, rest, massage, counter-irritation, etc. It is particularly in cases of chronic synovitis that the local hot-air bath of a temperature of from 300° to 400° F. is used with great success.

TUBERCULOSIS of the joint is usually due to infection from the bone, though it may in some cases be primary in the synovial membrane. The usual symptoms are swelling, due to effusion and to the thickened capsule; there is always a limitation of motion, and usually pain, due to the friction of two roughened joint surfaces, and marked and painful spasms of the muscles surrounding the joint, while atrophy of these muscles is generally to be noted. Immobilization of the joint, together with extension, are indicated as in joint tuberculosis elsewhere. This is, however, difficult to achieve in the upper extremity by any portable apparatus, though simple immobilization at the elbow and the wrist may be attained by proper splints. For thoroughly satisfactory extension, the use of the weight and pulley with recumbency in bed is essential, and even with these, satisfactory application of this form of treatment to the shoulder joint is very difficult, owing to the extreme mobility of the scapula. On account of the imperfection of methods of extension and immobilization in treating tuberculosis of the joints of the upper extremity, we turn the more readily to the use of iodoform emulsion and other substances by injection into the joint cavities, and in severe cases proceed to resection, typical or atypical. In conjunction with other methods, general tonic treatment should not be forgotten.

ACUTE SUPPURATIVE ARTHRITIS is sometimes found, due to the infection from a wound, or of hæmatogenous origin. All the signs of a severe and acute inflammation are present. The treatment is in all cases by incision and drainage and by immobilization of the joint. Ankylosis is often a result in spite of our best efforts.

INFECTIVE ARTHRITIS is seen following the acute infectious diseases. It has much the same clinical character as rheumatism, but it does not tend to suppurate, nor is it migratory.

The wrist is the most prone of any of the joints of the upper extremity to succumb to GONORRHŒAL ARTHRITIS. Its well-known obstinacy and intractability have made it an *opprobium medicorum*. Recently incision and irrigation of the joint have been made use of with gratifying results in this form of arthritis.

In ACUTE RHEUMATISM, besides the systemic manifestations, the joints are inflamed, painful, and tender, and the articular affections tend to migrate. Rheumatic arthritis is prone to attack the larger joints. In cases of chronic rheumatism, the joints are stiff and painful but not always swollen, while on passive motion a creaking may be elicited. The muscles may become greatly wasted, and there is a tendency toward fibrous and even bony ankylosis. The treatment of the acute form is by means of alkalies and salicylates and other appropriate drugs, together with heat, pressure, and rest. In the chronic forms the best results are obtained from massage and active and passive motion, the hot-air bath, the copious and long-continued use of lithia water, and a strict antirheumatic regimen.

RHEUMATOID ARTHRITIS, or arthritis deformans, is characterized by changes in the cartilages and synovial membranes with periarticular formation of new bone and great deformity. The cartilage is either thin or entirely absorbed, laying bare the bone, while at the ends of the joints osteophytes form that may cause even complete ankylosis. This is accompanied by a thickening and contraction of the ligaments and great atrophy of the muscles. Hypertrophy of the articular ends of the bones is common, though in some cases atrophy is observed. Neuritis is prone to occur as a complication. The treatment is by massage, forced passive motion, and hot-air baths, but the disease has a tendency to become pro-

gressive, and in severe cases but little benefit is derived from treatment of any kind.

A SPRAIN is produced when the motions of a joint are carried beyond their physiological limits, but stop short of permanent displacement of the articular ends. With this there is either a stretching or rupture of portions of the capsule or ligaments, accompanied by pain, swelling, ecchymosis, and limitation of joint motion with tenderness over the joint. Sprains are especially prone to occur at the wrist, though the elbow and shoulder are frequently affected. It is important to differentiate a wrist sprain from a Colles's fracture, and this can generally be done by determining the absence of crepitation and of an abnormal point of motion, and also by the fact that in Colles's fracture the hand is drawn toward the radial side with a more or less pronounced "silver-fork" deformity. This last condition is sometimes better appreciable to firm palpation than to the eye, especially when some time has elapsed since the receipt of the injury. The use of the *x*-ray will, however, in most cases make the diagnosis certain.

The treatment of a sprain is rest, elevation of the part, and compression, with the use of cold followed later by hot applications. The use of massage from the beginning is quite successful in skilful hands, while this with passive motion is always indicated after the subsidence of acute symptoms.

ANKYLOSIS may be due to contractures of the muscles, or to fibrous or bony union of the articular surfaces. Contracture of the muscles may in turn be due to disturbed innervation or nutrition of the muscle, or to myositis followed by degeneration of the muscle cells proper. The second variety of ankylosis is most often due to acute suppurative osteitis, joint tuberculosis, chronic rheumatism, or rheumatoid arthritis.

The treatment will depend upon the cause, and may consist of massage and forcible flexion and extension of the joint. These not availing, more or less extensive tenotomy and myotomy may be practised, or the joint itself may be excised. At the elbow, where, on account of the complexity of the joint, ankylosis is particularly prone to occur, a flail joint, the result of an excision, with all its disadvantages, gives nevertheless a much more serviceable arm than can be obtained by any other form of treatment for extensive fibrous or bony ankylosis of the joint. In ankylosis due to muscular contracture it is less to be recommended.

Quite a large number of cases are on record of loose bodies in the elbow-joint. Their pathological history is similar to that of loose bodies in other joints, such as the knee. The only treatment is removal by arthrotomy.

IV. AFFECTIONS OF THE MUSCLES, TENDONS, AND TENDON SHEATHS.

(*a*) *The Muscles.*—In no part of the body are the muscles and tendons grouped in such numbers about the bones as in the forearm, and in no part of the body do the affections of these structures stand out so prominently as in the upper extremity.

The commonest of all diseases of the muscles, if indeed the name of disease is applicable, is that condition of the muscles which results from long-continued use without sufficient repose to which the name *myalgia* has been given. The pathological condition present is in the main but an accentuation of the normal condition of muscular fatigue, and is attended by similar symptoms, namely, tenderness on pressure, "lameness" in use, and deficient response to ordinary physiological nerve impulse (*i.e.*, weakness in action), and, finally, involuntary and painful spasm, "twitching." These symptoms in turn are caused by too great an accumulation in the muscle of the chemical products of muscular activity, and this accumulation, again, may be the result of either or both of two factors: excessive production on the one hand, and deficient elimination on the other. As to the exact chemical bodies involved, the reader is referred to treatises on physiology; their exact nature is still a matter of dispute, but one of the best established of the waste substances is lactic acid, present in sufficient quantity to affect markedly the reaction of the muscle substance to delicate alkalimetric tests, and there is little doubt that this changed reaction of the muscle substance induces in its turn the precipitation of various "leucomains" which it is difficult for the ordinary blood current to remove promptly. So long as these decomposition products (uric acid, xanthin, hypoxanthin, acid phosphates) are not removed from the muscle the symptoms enumerated above will continue; with their disappearance the normal function of the muscle will return.

The exact locality of these morbid deposits is not entirely settled, but many facts point to the probability of their being located rather in the sarcolemma and in the perimysium than in the substance of the muscle proper. The facts which would indicate this are the aggravation of the tenderness at the muscular origins and insertions, and the spread of the myalgic affection throughout the fibrous tissues beyond the points of actual muscular insertion; indeed, in no part of the body is what passes for myalgic affection, or as very closely akin to it, more obstinate and troublesome than in the fibrous tissues just below the origin of the erector spinæ muscles, over the sacrum and the sacro-iliac synchondrosis. It is more than probable that consecutive upon a pure myalgia may occur a rheumatic form of periostitis from extension beyond the point of bony origin or insertion of a muscle by "contiguity of tissue." This is exemplified with peculiar distinctness in cases of myalgia affecting the muscles attached to the coracoid process of the scapula, where the coracoid process itself may often be found to retain for a long period a great degree of tenderness when pain may entirely have left the bodies, or the tendons of the muscles attached to it.

Excessive formation of waste products comes from over-use of the involved muscle; deficient elimination may be caused by use of the muscle under unfavorable conditions, or by exposing the member to untoward conditions after its severe use, thus interfering with its prompt rehabilitation. An amount of muscle work whose catabolic products would be speedily provided for under other circumstances may induce a severe myalgia if performed when the patient was suffering from want of sleep, as many a weary obstretician can testify; and it is notorious that sitting in a draught after active exercise will lead to "the cold settling in the limbs."

There is one form of this affection whose sudden and severe onset may lead to confusion in the diagnosis; this form more frequently attacks the erector spinæ group of muscles, or those of the abdomen, when it is known as a "stitch in the side." This form of myalgia is probably due to a gradual accumulation of fatigue products in the muscle, or possibly only in the fibres of a small portion of a muscle, to the point of irritating the affected fibres to a sudden, painful, and protracted involuntary contraction, the patient having been unaware of the soreness of that particular muscle through the accident of not having brought those fibres into play. When once the painful contraction has taken place, the irritability of the affected muscle becomes extreme and the whole muscle is brought more or less involuntarily into repeated action, to "test its soreness," and a more or less persistent myalgia is found to be established until driven off by the activity of the circulation or by the exhibition of suitable remedies. Such a sudden development of a latent myalgia among the muscles of the forearm has led in one instance I have known of to an erroneous diagnosis of rupture or dislocation of a tendon. The patient was a young woman engaged in wiping dishes; of a sudden a severe pain shooting through the forearm caused her to drop the dish in her hand, and certain movements of the fingers were from that time on, for many weeks after, painful and feebly executed.

The diagnosis of myalgia, as it appears in the arm and forearm, is not ordinarily attended with great difficulty. The history of fatigue, or exposure, or both, will generally suggest the diagnosis, while the presence of the

gouty or rheumatic diathesis, as conditions under which waste products are imperfectly removed from the tissues, will be allowed a certain weight in establishing the probabilities. In the upper arm the extensors (triceps) are most frequently affected, in the lower arm, the flexors and extensors with about equal frequency. Occasionally the coraco-brachialis or the anconeus may be affected alone, giving rise to rather obscure pains in the shoulder and elbow respectively. Such cases are readily overlooked in a careless diagnosis. Incidentally their deep location renders treatment more difficult. The tenderness over the affected muscle, the painful and imperfect function, and the occasional fibrillary spasm are the positive factors upon which we base a diagnosis, while the absence of fever, swelling or redness, the absence of tenderness about the joints, along the course of the nerves, or along the tendon sheaths will weigh against rheumatism, neuritis, and thecitis respectively. The absence of fibrous crepitation will also serve to aid in excluding this last affection. From painful affection of the bone or the periosteum it may be extremely difficult to differentiate a deep-seated myalgia; the absence of pain on jarring the limb, and its ready yielding, if recent, to the faradic current will serve to aid in identifying a myalgia.

The prognosis is good if treatment be instituted early; if treatment be too long postponed, and atrophy ensue, due partly to disuse and partly to local poisoning of the muscular substance by the "materies peccans" of the disease, the affection may prove very obstinate and intractable, but will in almost all cases eventually yield where the persevering co-operation of the patient can be secured. It is my firm belief, however, that simple myalgia, if severe and untreated, can occasion permanent disability.

The treatment of myalgia consists in efforts to throw again into solution those precipitates in the muscles whose presence impedes their function and causes the pain. This we seek to accomplish along certain rational lines, all tending to this common end.

Probably the first therapeutic efforts of sufferers from myalgia were directed toward keeping the affected part warm. The rationale of this lies in inducing a dilatation of the blood-vessels, which brings a larger supply of the solvent serum into contact with the offending precipitates, thus promoting their solution. With the increased advent of blood follows in turn an increase of heat, which in connection with the heat added from without induces an actual rise of the temperature of the part, which is likely to promote considerably the solubility of any precipitates. Recently this method of treatment has had its efficacy greatly enhanced by the devising of methods of exposing the affected limb to dry air at very high temperatures. Local hot-air baths may now be procured from instrument dealers by means of which an extremity may be exposed, without damaging the skin, to dry air at a temperature of 300° to 500° F.

Other ways of increasing the afflux of fresh serum to aid in the solution of precipitates are, first, counter-irritation, applied to the overlying skin by the use of iodine or other rubefacients, cantharidal blisters, or "firing" with the actual cautery; secondly, moderate, active use of the muscles, when practicable without causing too much pain; every athlete is familiar with the disappearance of "muscular stiffness" (the mildest grade of this disease) under fresh exercise; thirdly, massage of the affected parts is extremely useful, particularly in the more obstinate and chronic forms of myalgia; it acts partly by mechanically dislodging crystals or amorphous masses of precipitated matters, forcing them into the lymphatic circulation, and partly by greatly stimulating the local circulation.

Antirheumatic remedies, and the antirheumatic régime are also of use in controlling the pain of myalgia, chiefly by the solvent affect of alkalies and of the salicylates on the morbid deposits, and of these measures there is none that compares in importance with the ingestion of very large quantities of water.

While massage is our best weapon against chronic forms of the malady, especially in the presence of secondary atrophy, there is no agent whatsoever that will give the immediate and lasting relief that is to be obtained from the application of the faradic current, and no more grateful patients are encountered than those who have been relieved from the misery of a myalgia by the brief application of a mild current.

One special point it is important to notice in the treatment of myalgia of the upper arm—namely, this, that the muscles which move the upper arm have their origin on the trunk; and that their function is twofold, first, that of imparting voluntary movements to the upper extremity, and secondly, that of supporting the weight of the arm. This second function is not appreciated during health, but in the presence of a severe deltoid myalgia, the six to ten pounds weight of the arm dragging upon the lame muscle is a very considerable factor in increasing the pain and a serious obstacle to recovery. In all acute myalgias, therefore, affecting the muscles which pass from the trunk to the arm it is necessary to support the weight of the member by a firm bandage at the elbow. The most effective device for this purpose is a Moore's dressing for fracture of the clavicle, as described under the head of fractures.

Occasionally one sees cases of what are called "chronic sprains" or "strains," caused by the overuse of certain muscles, in which the pain is principally at the origin or insertion of the muscles. Tenderness and stiffness are prominent symptoms. Examples of this are seen in the so-called "BASE-BALL PITCHER'S ARM," "TENNIS ELBOW," etc. Such persistent overuse of a muscle may give rise to a local periostitis at one of the points of attachment of the muscle, possibly resulting in necrosis.

ACUTE MYOSITIS is occasionally encountered in the muscles of the arm as a result of pyogenic infection. The pyogenic type of this disease, however, is rare, and when present is but a secondary accompaniment to neighboring extensive septic processes. It may lead to necrosis of the muscles *en masse*, or to fractional sloughing, and solution of the muscle fibres in the purulent effusion.

The most common forms of myositis are those whose origin is SYPHILITIC, indeed it is more than probable that part of the rheumatic pains which precede or accompany the eruption of constitutional syphilis depend upon a light and acute irritative myositis.

A commoner form of syphilitic myositis is the CHRONIC INTERSTITIAL VARIETY depending upon a small-celled infiltration rising from the perimysium, and extending into and between the muscle bundles. These are destroyed by pressure atrophy, and become transformed into connective tissue with gradual loss of the muscle. It is a diffuse process within the muscle, and is at first generally attended with pain.

GUMMATOUS MYOSITIS may develop as a slowly growing, and perfectly painless infiltrate in the muscles. Accompanying the gummatous process there are usually found more or less extensive inflammatory changes. More commonly, however, the growth of the gumma is more rapid, and pain, increased by touch and motion, is a marked symptom. The muscle in all the more rapidly growing gummata is in a state of constant contraction, the growth at first moves with the movements in the muscle. As it increases in size it becomes softer in consistency, and the muscle assumes a condition of permanent contracture.

Gummatous myositis often advances beyond the muscle, and comes to involve the fascia and subcutaneous tissues. It becomes more prominent, softer and less movable, and finally breaks through the skin, leaving a sinuous ulcer from which necrotic masses, chiefly fascial, are extruded. After healing, which requires weeks or months, a cicatricial tissue remains which binds together the muscle, fascia, and skin (Hartley).

PROGRESSIVE MUSCULAR ATROPHY is a disease which manifests itself most distinctly among the muscles of the arm. It is, however, essentially a nervous disease and not a disease of the muscles; its consideration here, in connection with the muscles, is for greater convenience only. The nerves supplying the atrophied muscles may be affected anywhere along their course, but the principal site

of the lesion is in the anterior gray columns of the spinal cord. However general the disease may subsequently become, it is at first localized, and the upper extremity is by far the most frequently involved. Affection of the right hand is said to be considerably more frequent than that of the left, and of the muscles, either the interossei or those of the ball of the thumb first succumb. The disease, in fact, at first simulates an ulnar neuritis, but careful study will indicate the involvement of certain muscles which are supplied by other nerves. From the thenar muscles and the interossei, the disease commonly creeps up the forearm and thence to the arm, or it may skip the forearm and pass into the arm, although the triceps extensor muscle is usually spared. It may come to a standstill in either of these two places, but may involve the muscles of the shoulder, especially the deltoid. Beginning most frequently on the right side, both upper extremities become involved sooner or later. In other instances in which the extremities are involved the atrophy begins in the deltoid (here again the right first). Succeeding the deltoid, the scapular and trapezius muscles may be involved in any order, while a grotesqueness of effect is often produced by reason of certain adjacent muscles retaining their natural size or even being hypertrophied. This is particularly the case with the anterior part of the trapezius, which is almost never involved. While the shoulders remain exclusively affected, the arm and forearm may retain their usefulness and strength, but the power of lifting the arm from the side, and especially of raising it above the head, is lost, and if the patient wishes to lay hold of anything he must swing his arm forward with a jerk till the object is brought within reach of his fingers.

The muscles of the trunk become at times involved, the pectorales, the latissimi, the serrati, and the intercostales, and even the diaphragm and the abdominal and lumbar muscles.

The muscular atrophy is generally accompanied by a corresponding wasting and retraction of the skin, so that this continues to be applied to the muscles in the usual manner. In some instances, however, this is not the case, and in these a baggy condition of the skin is added which gives its subject an appearance which has more than once rendered him valuable to the showman as the "elastic skinned man," etc. It sometimes happens, on the other hand, that the atrophy is obscured by an accumulation, between the muscles and skin, of adipose tissue, and an appearance of hypertrophy rather than of atrophy may be produced in consequence.

A second muscular symptom, more or less distinct, is fibrillar contraction. This consists in wave like contractions running along small bundles of muscular fasciculi. These contractions occur spontaneously, or are excited by some slight stimulus, as a breath of air or a dash of water, or by tapping the patient with the fingers or passing a galvanic current through the parts, and this too in any stage of the disease, except that they do not occur in muscles wholly destroyed. Sometimes they can be felt by the patient; at other times he is wholly ignorant of them. They are not invariably present, and often they have been seen in muscle atrophy from other causes; they possess, however, a certain amount of diagnostic value, especially when spontaneous. Coincident with the wasting of muscles is their loss of function. Sensibility is in many cases unchanged, the tactile sense being as delicate as ever, and pain, except accompanying the cramps and chronic contractions of groups of affected muscles, which sometimes occur, is absent. At times, however, the atrophy is preceded by painful paroxysms, which may or may not accompany the chronic contraction referred to. The pain is sometimes in the course of nerve trunks, but is as often diffuse, as if the muscles themselves were its seat. At other times it is variably described as a soreness, an aching or a rheumatic pain. Morbid sensations, as those of cold, numbness, and formication may be experienced. Reflex excitability may be increased, while the knee jerk is said to be absent. Unusual sensitiveness to cold is sometimes noted, and so also is the loss of muscular power under its influence, which is again restored by artificial warmth (Tyson).

The lipomatosis, which has already been alluded to as affording, in some cases of muscular atrophy, somewhat the appearance of the pseudo-muscular hypertrophy, may to the casual observer obscure the diagnosis of this disease. Pseudo-hypertrophic paralysis, however, almost invariably first asserts itself in the lower extremity.

SYRINGOMYELIA is another of the central nervous diseases which finds its most marked expression in the secondary changes it induces in the sensory, trophic, and motor functions of the arms. The symptoms are almost always bilateral, but a few cases have been observed in which but one side of the body was affected. The most common type is that in which the most salient features are loss of perception of pain and temperature, with retention of the tactile and muscular senses, combined with atrophy of the arms similar to that observed in progressive muscular atrophy. The atrophy usually appears in the small muscles of the hand and gradually extends upward, involving consecutively the arm, forearm, and shoulder muscles, or it may first appear in the shoulder and upper muscles and later descend to the hand. The difference depends upon whether the lower cervical gray matter is first affected with extension upward of the process, or whether the upper cervical enlargement, in which are located the centres for the shoulder muscles, is first affected.

Corresponding with the atrophy there is naturally a weakness of the muscles which may go on to complete paralysis. Trophic disturbances are common. Changes in the joints and bones, very similar to those observed in tabes, occur in about ten per cent. of the cases. The joint changes consist principally of enlargement of capsular ligaments, loosening of the joints, thickening of the capsule, changes of form in the ends of the bones, and development of bony spicula in the capsular walls. The further changes resemble those in tabetic joints.

Painless fracture of the bones may occur from very slight causes, as in the case of a man who fractured the radius while kneading dough. Various atrophic changes in the skin are frequent, such as herpes, eczema, and even deep ulceration and gangrene; in rare cases amputation of the hand may be necessary; or there may be simply vaso-motor changes causing lividity and coldness of the skin or the opposite, or œdematous swelling of the hand. There may be sweating or dryness of the skin. The nails may become dry, cracked, and brittle and may drop off.

An obtrusive symptom which is sometimes observed is the painless felon, similar to that which occurs in Morvan's disease. These felons occasion deep ulceration and necrosis of the distal phalanges of the fingers so that they may drop off. Notwithstanding this extensive ulceration the felons are painless, owing to the analgesia present (Prince).

For a more accurate differential diagnosis of these different secondary muscular dystrophies, and for a more exact discussion of their pathology and treatment, the reader is referred to articles in this work on diseases of the nervous system.

Spastic rigidity of the arms is often one of the earliest signs of CHRONIC HYDROCEPHALUS, even before the skull begins to enlarge, and convulsions may be present from time to time. In congenital spastic rigidity, due to sclerosis or defective development of the cortex cerebri, the spastic condition is usually confined to the legs.

In PARAMYOCLONUS MULTIPLEX, as the name of the disease implies, the contractions of the muscles appear in paroxysms and the muscles involved are usually the biceps, deltoid, and triceps in the arms, and the quadriceps femoris and calf muscles of the lower limbs. Myoclonus multiplex is a disease of adult life, and may be differentiated from chorea, which is usually seen in childhood. Sometimes the muscles in myoclonus are exceedingly irritable.

Sometimes, as the result of infantile cerebral paralysis, or from reasons developing later in life, the muscles of

the hand are affected by a slow, constant movement, so that the fingers assume curious constrained and unusual postures, being moved into extreme or forced extension, flexion, pronation, or supination. This condition is called ATHETOSIS, and is separable from chorea in that the movements are slower, and are limited to the fingers and wrists, the arm escaping.

Absolute loss of power in one hand and arm, without the necessary development of subsequent deformity, results from cerebral or peripheral lesions as a rule, being rarely spinal in origin, and is called BRACHIAL MONOPLEGIA. Although the onset of a monoplegia due to cortical, sub-cortical, or capsular causes is sudden, the reactions of degeneration do not come on for a long period of time in such cases, because the muscles in the paralyzed area are still connected with the trophic centres in the cord, and this affords us a valuable point in differential diagnosis. In all cases of brachial monoplegia due to peripheral lesions we find that atrophy of the muscles comes on very rapidly from cutting off of the muscles from their trophic centres in the spinal cord.

(*b*) *The Tendons.*—The want of protection of the tendons in the forearm is the reason of their frequent accidental division from incised wounds near the wrist. In the event of such division the proximal end will retract an inch or more into the tissues of the forearm, and naturally the function of the accompanying muscle will be totally suspended. Where several of these tendons have been divided at once, there may be considerable difficulty in identifying the corresponding proximal and distal ends. In any clean wound, however, union by suture should be attempted; nor would the mistaken apposition of the proximal end of one tendon to the distal end of another prove as serious a disaster as the failure to unite the severed tendon ends. In fact an intentional transplantation of the proximal end of one tendon to the distal end of another has recently been practised with brilliant success in some cases of infantile paralysis, with a view to imparting vicarious function to the paralyzed members. In uniting multiple sections of the tendons in transverse incised wounds of the wrist and forearm, it is important that the union should be at least between tendons traversing the same compartment of the annular ligament.

An occasional result of a severe sprain is the DISLOCATION OF THE TENDONS about the affected joint. The long head of the biceps is oftenest so affected, being displaced from its groove in the humerus. The flexor carpi ulnaris is sometimes injured in this way, and the tendon of the extensor communis digitorum, which runs to the index finger, is not infrequently torn from its bed at the back of the wrist, owing to the fact that the portion above the annular ligament stands at quite an angle to the portion below. Its displacement is always to the radial side. In cases of dislocation of the tendons, the muscles can still contract, but the tendon can be felt to move in its abnormal position, while the extremity suffers a partial loss of function from the mechanical disadvantage under which the muscle works.

These accidents may be treated by replacing the tendon and keeping it in position by a splint. This not availing, the tendon may be cut down upon and the torn sheath sutured or a new sheath formed by dissecting up a band of periosteum.

Among the traumatic affections of the tendons we occasionally meet with instances of complete rupture. This occurs either in the course of the tendon proper, or, more frequently, at the attachment of the tendon to the bone, but rupture at the musculo-tendinous junction is almost unknown. When the tendon is inserted into a special epiphysis, as the triceps into the olecranon process, the biceps into the tubercle of the radius, and the supinator longus into the styloid process of the radius, so-called rupture of the corresponding tendons is usually accompanied with tearing off of the epiphysis and more or less stripping up of the adjacent periosteum, constituting what is known as a fracture "par arrachement." Although the tendon is the part which usually gives way under strain on a muscle, the muscular fibres themselves may, in rare cases, be more or less extensively torn across, especially after long and exhaustive diseases, such as typhoid and scarlet fever. Contusion of a muscle in a state of tense contraction may, however, bring about a subcutaneous division of its fibres sufficient to cause a pronounced diastasis of the divided portions. The tendons of the arm most frequently the subject of rupture are the long head of the biceps, and the pronator radii teres; the radial attachment of the biceps, the triceps, the deltoid, and the pectoralis major have been reported as torn from their insertions. It is not likely that rupture of a healthy tendon can occur except when the muscle is suddenly and unexpectedly exposed to severe additional strain when already in a state of contraction. The accident is generally accompanied by sudden and violent pain, by complete loss of power in the muscle, and by considerable impairment of function in the limb. When seen soon after the occurrence of the accident a more or less marked depression can be felt over the site of the rupture; this depression may later become filled with extravasated blood or effused lymph and may in fact become converted into an elevation. Where the fleshy body of a muscle is torn across, unless the muscle be one lying very deep, the depression will be likely to be quite deep and quite persistent. Such an evidence of an hiatus in the continuity of a tendon or muscle is almost pathognomonic of the lesion.

The treatment will vary, according to the importance of the affected muscle and the amount of disability incurred, from simple rest with pains to keep the limb in a position to relax to the utmost the affected muscle, to more or less elaborate operative procedures for the restoration of the continuity of the lacerated tissues by suture. It should be remembered that contractures may subsequently develop in consequence of muscular or tendinous ruptures.

The tendons themselves are rarely the subject of disease which does not also involve their synovial sheaths as well. They may become necrotic in suppurative processes which have invaded their sheaths, and in this case their separation will take place at the point where their intrinsic blood-vessels have been destroyed. The tendons are sometimes the seat of deposits of urates, and not infrequently undergo calcareous infiltration in advanced life. Ossification of their distal ends is also sometimes observed, and in some cases there is an anomalous development of sesamoid bones at the point where the tendons may form an angle in passing over bony prominences. Rheumatic deposits are sometimes found near the proximal end of the tendons.

(*c*) *The Tendon Sheaths.*—Much more common than disease of the tendons themselves is disease of the synovial membrane which surrounds them. The exact pathology of the SIMPLE IRRITATIVE FORM OF TENOSYNOVITIS is not very perfectly understood. From its etiology and course the pathological condition is strongly analogous to that which has been discussed under the head of myalgia, and is probably due to an alteration of the synovial fluid and possibly of the endothelial cells lining the sac. It is observed to occur under conditions strictly analogous with those which induce an attack of myalgia, *i.e.*, exposure to cold and over-use of the parts. It is generally accompanied with lameness and tenderness over the course of the tendon, and characteristic of the condition is the crepitation which follows contraction of the muscle. Rest, heat, and counter-irritation are the best means for relieving the difficulty.

In addition to the simple irritative form, a septic, a rheumatic, a syphilitic, and a tuberculous form of tenosynovitis are recorded.

The SEPTIC FORM is almost invariably secondary to septic processes outside of the tendon sheaths, and in septic tenosynovitis of the forearm the locus of primary sepsis is most frequently the hands and fingers. The disease is accompanied with a purulent effusion into the tendon sheaths, giving rise to tender oblong swellings, ill defined on account of the distention due to accompanying cellulitis, and lying parallel with the axis of the limb. The

surrounding tissues are usually sufficiently involved in the pyogenic process to give rise to heat, redness, and swelling of the surface. Suppurative tenosynovitis has been known to follow gonorrhœal rheumatism of the joints.

The treatment of purulent thecitis consists in laying open the tendon sheaths freely, though not literally from end to end lest the tendon escape from its bed. Only in rare cases would it be justifiable to divide the annular ligament of the wrist or even to open its compartments. Great effort, however, should be made to irrigate the sac most freely with antiseptic solutions through the liberal incision above and below the bridge of tissue which it may be deemed wise to leave to serve as a bridle to hold the tendon in its bed, and particular pains should be taken to force the irrigating fluid to pass under this bridge of tissue.

In dressing wounds, whether operative or otherwise, of the tendons or of the tendon sheaths, it must be borne in mind that the vascular supply of these tissues is limited, and that in consequence when they have been exposed to the air it is necessary to provide carefully against their desiccation in order to avoid necrosis. In all aseptic conditions of the tendon sheaths this may be accomplished by covering the exposed tissues with impervious protective strips of gutta-percha, rubber, or prepared mackintosh. In septic processes the use of impervious dressings is contraindicated, and provision against desiccation must be made by means of wet dressings, frequently renewed.

Like all diseases of the fibrous system, tenosynovitis is very prone to occur in arthritic subjects, and the RHEUMATIC FORM OF TENOSYNOVITIS has a very disagreeable tendency to become chronic. In the acute stages alkalies and the salicylates will afford relief to the patient. In the later stages lithia and the iodide of potassium are the most serviceable drugs available; while the exposure of the limb to high temperatures in the hot-air bath, together with massage, and active and passive motion carried on in spite of the soreness, will do much to restore the supple action of the arm.

The TUBERCULOUS FORM OF TENOSYNOVITIS begins in a very insidious fashion. It may be primary in the tendon sheath, but is frequently secondary to a tuberculous process in the adjacent joints. It is, like most tuberculous processes, of very slow growth, covering a period sometimes of years, with times of improvement under rest, but with great proneness to recur as soon as the limb is again put to its customary use. It develops frequently after some traumatism such as a sprain or a contusion, and the differentiation from the simple irritative or from the rheumatic form is not at first easy. After a while there will almost always be developed along the course of the tendon the characteristic flat or oval swelling caused by effusion into the sheath and thickening of the walls of the sheath itself. This swelling may take on more or less of an hour-glass shape from confinement of the tendon beneath the annular ligament. The disease may remain confined to one portion of a single tendon sheath, but tends to extend both upward and downward; also to attack neighboring tendons and even to invade underlying joints.

According to Park, there are two pathological forms of the disease: one is a fungous form distinguishable by the growth of exuberant granulation tissue of a gelatinous appearance surrounding the tendon on the inner side of its sheath. In the other form, known as hygroma, the inner surface of the tendon sheath is covered with small growths, which become detached, forming small, hard kernels known as rice bodies. These rice bodies are the result of fibrinoid degeneration, *i.e.*, the degenerated villous growths which are fibrinous in character become loosened, forming free kernels. Until recently, this form of disease was supposed to have no connection with tuberculosis. It is now distinctly established that these bodies contain tubercle bacilli. The same condition may be found in tuberculous joint disease where they develop from a fibrinoid degeneration of tuberculous granulations on the synovial fringes. If the disease is allowed to run its course, suppuration ensues, forming sinuses involving the skin which eventually breaks down. These with the resulting cicatrices greatly impair the use of the hand.

The treatment of tuberculous tenosynovitis is essentially the same as that of tuberculous joint trouble, and consists at first in the immobilization of the arm by suitable splints, with moderate pressure, together with the administration of appropriate tonics and careful attention to hygiene. The possible usefulness of dry air in the hot-air bath is not altogether settled, though it might seem a rational therapeutic measure. It is essential to differentiate positively the tuberculous form of the disease from the simple irritative and the rheumatic form. Massage, and movements, active and passive, so pre-eminently useful in the treatment of the two latter forms, is absolutely and positively contraindicated in tuberculous synovitis. Failure to secure improvement by the above means would justify us, as in cases of joint tuberculosis, in proceeding to operative measures. The simplest of these consists in aspirating the fluid contents of the tendon sheaths and in injecting into them a ten-per-cent. emulsion of iodoform. Should this fail to control the process, the tuberculous area should be cut down upon, the blood supply to the arm being first cut off with an Esmarch bandage, and any suspicious granulation tissue scraped away with a small curette. At any point where the tendon itself seems hopelessly affected, it should be freely resected and an effort should be made by splitting and grafting the tendon to compensate for the defect. Even should this be impossible, the function of the tendon may better be sacrificed than to expose the patient to danger of loss of the limb or even of life.

SYPHILITIC TENOSYNOVITIS may exhibit itself in an acute and chronic form, not easy to differentiate by symptoms alone from simple and rheumatic inflammation of the tendon sheaths. Both of these forms of syphilitic thecitis are seen in early syphilis, and I have myself observed one marked case ending in resolution after some months of treatment, in a case of hereditary syphilis accompanied with syphilitic pachymeningitis.

The gummatous form is almost invariably very late in development, occurring often fifteen or twenty years after infection. It is recognized as a round or spindle-shaped swelling involving the tendons. It grows slowly and painlessly, remaining as a gummatous swelling, becoming calcareous, or extending to the surrounding tissues, the fascia and the skin.

SYNOVIAL CYSTS OF THE TENDON SHEATHS, otherwise known as weeping sinews or ganglions, occur with greatest frequency about the wrist, whether just above or just below the annular ligament. There are cases met with, however, in the lower part of the forearm, both on the flexor and on the extensor tendons. Their exact pathology is a matter of dispute, but it is fairly well established that they rarely communicate with the synovial sac proper. They not infrequently contain rice bodies such as are found in the synovial sac in cases of tuberculous disease, but their almost invariably benign course would make it seem improbable that their origin should be tuberculous. These little cysts frequently disappear spontaneously, and often their disappearance can be hastened by moderate pressure long continued. More obstinate cases can be dealt with by free subcutaneous puncture with a sharp bistoury or tenotome and the expression of their contents by digital pressure into the surrounding cellular tissues. Some cases may demand free incision and extirpation of the cyst walls, an operation which must be conducted with careful antiseptic precautions, on account of the close association and occasional continuity of the cyst with the tendon sheath proper.

V. AFFECTIONS OF THE BLOOD-VESSELS.

(*a*) *The Arteries.*—The blood-vessels of the arm are subject to the same diseases as the blood-vessels elsewhere in the body. The ANATOMICAL POSITION OF THE RADIAL ARTERY is important from its frequent use for taking the

pulse, and it should be remembered that it may be absent in rare instances; or it may be much smaller than normal, terminating in muscular branches above the wrist; or it may lie upon the deep fascia instead of beneath it; or it may be covered by fascia so thick and hard that the pul sation cannot readily be transmitted to the finger tips; finally, it may turn backward beneath the extensor muscles of the thumb. When in its normal position it is easily felt, pulsating almost subcutaneously over the bones of the wrist.

ATHEROMA OF THE ARTERIES manifests itself through thickening of the vessel wall, either localized or diffuse, and often accompanied by the deposit of calcareous salts until a condition of the vessel is produced well expressed by the term "pipe-stem artery." It is most readily appreciable in the radial artery near the wrist. Its chief importance in this connection is not with regard to the function of the vessels of the arm, but as an indication of the condition of the vascular system throughout the body. The vascular sclerosis will often be found more marked in the right arm than in the left, in individuals such as stone cutters and blacksmiths who habitually perform much heavier labor with that arm than with the left. When this condition of arterio-sclerosis is found to be present, it is an important guide to the surgeon in leading him to make a guarded prognosis as to the result of severe operation anywhere in the body.

ANEURISMS occur in the vessels of the arm as elsewhere. They may be present at any age; indeed Schmidt reports an aneurism of the radial artery in an infant of eight weeks.

The traumatic forms affecting the arm are chiefly those springing from the axillary artery and showing in the arm pit. The arterio-venous form of aneurism was formerly quite a common occurrence when venesection was more generally practised. The adjacent artery being wounded by the incision which opened the vein, adhesions form between the two vessels and part of the arterial blood is thrown into the vein at each pulsation, the vein greatly dilating under the strain.

CIRSOID ANEURISMS are occasionally met with on the forearm. They are formed of dilated and tortuous arteries. In a case that came under my observation, the tumor extended from a little below the elbow almost to the wrist, and was about three inches wide. On operation a mass of dilated arteries was found lying in the superficial fascia, fed by numerous branches perforating the deep fascia from below. The treatment of this form of aneurism, which stands on the border line between tumors and malformations, consists in thorough extirpation, approaching the mass of pulsating vessels from the periphery and tying all the feeders at their point of emergence from the deep fascia. With careful dissection, working from the ends toward the centre of the tumor, dangerous hemorrhage can usually be avoided. The diagnosis of aneurism can usually be made by observing that the tumor has an expansile pulsation which ceases on application of firm pressure on its proximal side. In the case of cirsoid aneurism in which the feeders are numerous and come from the parts directly underneath the tumor, pressure on the proximal side will not suffice to interrupt the pulsation of the mass. A characteristic bruit can in most cases be heard over the tumor. The treatment of aneurism of the upper extremity does not differ from the treatment of the condition elsewhere.

(*b*) *The Veins.*—The veins of the upper extremity are subject to the same affections as those elsewhere in the body; such as wounds, phlebitis, thrombosis, and varices.

The condition of the veins of the hand and forearm is a valuable index of the condition of the general circulation as regards aëration of the blood and possible obstruction to the venous circulation. These veins dilate when the heart is weak, or when there is any impediment to the return circulation in the domain of the vena cava superior.

PHLEBITIS may be caused by inflammation near the vessel, by thrombus formation, by traumatism, or by direct infection. It gives rise to pain and tenderness in the course of the vessel, to œdema and discoloration of the skin, and if at all extensive, systemic symptoms occur which are those of mild or severe sepsis.

The treatment of simple phlebitis consists first of all in rest, which should be insisted on as most important to prevent the detachment of emboli. Next it is necessary to secure as near an approximation to asepsis of the intestinal tract as may be practicable, and finally some benefit may be expected from the use of antiseptic and stimulating substances applied along the course of the affected vein, such as a fifty-per-cent. ointment of ichthyol or Credé's silver ointment; the object of the treatment being to maintain the integrity of the thrombus within the inflamed vessel until such time as shrinking of the coagulated fibrin may allow a partial restoration of the vascular canal, and to stimulate the absorptive function of the perivascular lymph channels. Upon the first indication of septic infection of the thrombus, as evidenced by chills and septic fever, or by local abscess formation, it is proper and necessary to incise the tissues freely over the affected vessel, to clean out the septic clot, and establish free drainage. During such an operation it may be possible to restore the patulousness of many adjacent veins which may have become thrombotic, by extracting from their lumen long, more or less firm clots of coagulated blood and fibrin. Great care, however, must be used in manipulation of the affected limb to avoid breaking loose portions of the blood clot within the veins which might be carried as emboli to the lungs or to the brain, and give rise to dangerous or even fatal infarctions.

THROMBOSIS is due to conditions that slow the blood stream associated with abnormal conditions of the endothelial coat. It gives rise to sudden and severe pain and to œdema on the distal side of the coagulum. The treatment is essentially that of the phlebitis, which is an almost invariable attendant.

VARICES are rare in the upper extremity, owing to the less unfavorable action of gravity as compared with the lower extremity, but they may occasionally be found.

VI. AFFECTIONS OF THE LYMPHATIC VESSELS, GLANDS, AND BURSÆ.

(*a*) *The Lymph Vessels and Lymph Glands.*—In considering the affections of the lymphatic system of the arm, one anatomical peculiarity should be borne in mind—namely, this: that the greater part of the lymphatic current from the hand and forearm passes directly to the axillary and subscapular nodes without traversing the epitrochlear gland and the other lymphatic nodes at the bend of the elbow. The importance of this course of the lymphatic canals is indicated in cases of septic and malignant disease of the hand, as some cases on record tend to prove that the lymphatic vessels, as compared with the lymphatic nodes, may with considerable impunity serve in the transmission of both septic and malignant particles. Thus in cancer of the hand, with more or less extensive involvement of the axillary nodes, it has been recorded in some cases that amputation of the hand and radical extirpation of the axillary lymphatics has succeeded in leaving the patient free from recurrence of the disease, and in a similar manner we frequently find the axillary glands fatally compromised and breaking down into abscesses with the lymphatic vessels, by which infection from the hand must have travelled, remaining to all appearances intact. It behooves the surgeon in all cases of disease of the distal part of the upper extremity to examine with care the condition of the cubital and axillary glands and to palpate also the course of the deeper lymphatic vessels, which is to all intents and purposes that of the main arteries.

The EPITROCHLEAR NODE is situated in the bicipital sulcus just in front of the inner epicondyle of the humerus. It is one of the first glands to become enlarged and indurated in the general adenitis of syphilis.

ELEPHANTIASIS appears occasionally in the arms, but more rarely than in the lower extremities. LYMPHANGI-

of the wrist and in the supinators, with the occasional exception of the supinator longus. The wrist drops and the fingers are flexed at their distal joints. Some extension of the fingers, however, can be obtained through the action of the interossei and lumbricales. The typical distribution of the anæsthesia after actual division of the nerve above its cutaneous branches is along the outer part of the arm from the insertion of the deltoid to the lower third of the forearm, and there is more or less affection of the sensation of the dorsum of the hand, though in many cases there is little or no involvement of sensation.

The ULNAR NERVE is more exposed to INJURY than any other nerve in the body. In the wrist, at the elbow, and in the upper arm the nerve is liable to division from incised wounds, to pressure or contusion, or to involvement in fractures of the bone. Sometimes an apparently spontaneous ulnar neuritis is observed in persons otherwise in good health.

One peculiar accident is liable to affect the ulnar nerve as it passes behind the inner condyle of the humerus, namely, DISLOCATION from its bed. This accident is accompanied with more or less neuralgic pain referred to the region of distribution of its cutaneous branches, and with more or less involvement of the functions of the muscles to which it is distributed. The pain as well as the motor symptoms will be most marked when the arm is flexed. In short there is excited in the nerve at this point a localized neuritis. The accident, which is rare, may occur spontaneously during violent use of the arm, as in ball-playing and gymnastic exercise, or as the result of a contusion. Pain, numbness, and tingling along the ulnar side of the forearm and of the hand will indicate the moment of its occurrence and a cord can be felt running along the inner side of the epicondyle which reveals itself as the dislocated nerve through the aggravation of all these symptoms when pressed upon by the examining finger. To avoid extension of the neuritis and all the undesirable sequelæ of nerve degeneration, it is important that the nerve should be returned to its bed and securely fastened there. For this purpose a free incision should be made over the course of the dislocated nerve and a firm flap of connective tissue should be dissected up from the inner side of the condyle and turned outward over the nerve so as to bind it in its proper bed. The edge of this flap of connective tissue should be sutured to the capsular ligament of the elbow joint or to the periosteum of the humerus. It is wiser not to allow the needle to pass through the nerve sheath for fear of exciting neuralgic pains. The arm should be put up and fixed in extension and this position maintained until the parts shall have firmly united. If the symptoms of neuritis in the mean time have disappeared, the limb should be treated with massage, faradization, counter-irritation, active and passive motion, etc.

The MEDIAN NERVE is often INJURED, most frequently in incised wounds of the wrist. In the forearm it suffers in case of fracture of the ulnar and radius, and just above the elbow its course to the bicipital groove exposes it to injury. The nerve perforates the pronator radii teres, and it is possible for it to be injured in forcible contraction of this muscle without direct external violence.

The MUSCULO-SPIRAL NERVE is generally the sufferer in crutch paralysis from pressure in the axilla. Its close connection with the humerus leads to its frequent INJURY in case of fracture and to its frequent involvement in the callus or between the fragments. The most frequent cause of the paralysis is, however, damage to the nerve during sleep, the patient lying upon a hard bed with his arm under him. This is seen particularly in drunkards. In many cases this injury of the musculo-spiral nerve is due not so much to pressure as to stretching of the plexus by prolonged extension of the arm above the head. It is important for the surgeon to bear this in mind, as it is the frequent cause of arm paralysis after anæsthesia. The prognosis in paralysis of this description is almost invariably good; the most potent therapeutic agent being faradization of the affected muscles.

Progressive muscular atrophy and syringomyelia, together with the other spastic and paretic affections of the arm, though more properly due to nerve influences than to actual affections of the muscle, have nevertheless, for the sake of convenience, been treated above under the head of affections of the muscles.

VIII. HYSTERICAL LESIONS.

The elbow is a favorite seat for hysterical lesions, and the arm as a whole is frequently declared by the patient to be powerless, or may be held by perverted volition in some constrained attitude which may be the more natural one of extension, or of partial flexion, or again some strange or bizarre position from which the patient declares herself unable to move it.

The differentiation of hysterical from organic disease of the arm may be extremely difficult. Hysterical affections simulate especially disease of the joints. The differential diagnosis has been formulated by Dercum as follows: Hysterical disease of the joints is not associated with deformity and shortening of bone, nor with the formation of pus, nor with the local rigidity, nor with the septic temperature that is seen in tuberculous diseases. The stiffness is caused by contracture of the muscles, which is usually much more extensive than in organic disease, and the pain is usually more diffuse and more spontaneous. There are, moreover, characteristic mental and physical stigmata present. The hysterical patient dreads to move or assist in the examination of the limb, and obviously dwells upon each symptom, while she is very apt to have segmental anæsthesia in the affected limb or even hemianæsthesia of the body. A very significant symptom is paralysis of the limb, which is never present in tuberculous joint disease. Finally, under full etherization the hysterical joint is found to be freely movable in all directions. It must not be forgotten, however, that hysterical symptoms may be added to those of genuine organic disease of the joint.

Hysterical paralysis may be caused by emotion, such as fright, anger, chagrin, or disappointed love. It may vary in degree from slight loss of power to total palsy. The deep reflexes of the affected side are usually increased and the skin reflexes abolished. The tendency to contracture is often marked; some cases, however, present a flaccid type. In mild cases the nutrition of the limb is not affected, but in severe cases of long duration slight but distinct loss of volume may be noted. True atrophy with reaction of degeneration is practically unknown, and when present must throw a doubt over the exactness of the diagnosis. Hysterical paralysis is often accompanied also with anæsthesia or hyperæsthesia. The anæsthesia is likely to be sharply defined and limited to the paralyzed part. The boundary of the anæsthetic area will be at right angles to the long diameter of the limb. The paralyzed part may become œdematous and blue or mottled. The hyperæsthesia accompanying hysterical paralysis is usually hyperalgesia. This hyperalgesia may be attended with contracture. The painful cramp-like state of the muscles causes the patient to cry out and to shed tears. Hysterical paralysis is not as a rule confined to the distribution of particular nerve trunks; in other words, it is central, not peripheral. Contracture is very likely to coexist with paralysis in hysteria, still this is not a constant rule. Neither is the reverse true: that a contracted limb or muscle is always paralyzed. Hysterical contracture is most obstinate and resisting, being very difficult to overcome even with great force. Moreover, the antagonistic muscles are involved; in other words, the limb is drawn into a vise-like immobility. The contracture is sometimes so persistent that it does not relax even in sleep. It does relax, however, under ether or chloroform.

The duration of hysterical paralysis may be greatly prolonged. Some cases recover promptly, but others persist so long and simulate so closely the effects of organic disease that even the most careful observer may come to distrust the exactness of his diagnosis. The

pital, and certain members of the medical and hospital corps were left with the troops to treat the lighter cases, to give immediate assistance in emergency cases, and to send to the hospital those who could not be treated to advantage in their company quarters. With a sufficiency of experienced medical officers and well-trained members of the hospital corps, there is no difficulty in organizing the medical and hospital forces of various detachments of regular troops into a hospital service competent to meet all the needs of such a special expedition; but if in the opinion of the chief surgeon the available personnel and supplies are insufficient for the purpose, a requisition is made on the surgeon-general of the army to supply deficiencies.

In time of war, however, the regiment is the unit of organization for masses of men. Ordinarily it consists of ten or twelve companies of about 100 men in each; but the number of companies and of men varies in accordance with Congressional acts affecting the organization of the army. At present the regiment of infantry consists of three battalions of four companies each. The company has, when full, an enlisted strength of 111 to 128 men, and the regiment aggregates 1,413 to 1,617 commissioned and enlisted. The regiments of volunteer infantry now serving in the Philippine Islands also are three-battalion regiments, aggregating, when full, 1,342 officers and men. Congress has authorized to each a surgeon and two assistants, the surgeon having the rank of major and the assistants that of captain and first lieutenant, respectively. This medical force is insufficient for the performance of all the duties incidental to the care of so large a command. There should be at least three assistants, one for each of the battalions. As the strength of the regiment varies from time to time, according to existing legislation, the medical provision authorized for it is also variable. At the present time there are allowed to each regiment one hospital steward, three acting hospital stewards, and twelve privates of the hospital corps. Two four horse wagons are allowed for each hospital and three or four ambulances, or at the rate of one ambulance for every four hundred men of the effective force. If members of the hospital corps cannot be obtained as drivers, the Quartermaster's Department is authorized to hire civilians for this purpose. The tentage consists of four hospital tents, two of which are used as wards, one as dispensary and for storage, and one as a mess tent. Each hospital tent is fitted up for the care of five patients. There are in addition to the hospital tents two common tents for non-commissioned officers, three common tents for privates, and one common tent as a cook tent. The allowance of medical supplies and hospital property is very liberal, and is fixed by the surgeon-general. It consists of two medical and two surgical chests, a sterilizer, a filter, and hospital corps and orderly pouches; chloride of lime as a disinfectant; cream, farina, whiskey, and castile soap as hospital stores; folding field furniture with desk, food and mess chests, and an ample supply of bedding for ten patients, together with the many miscellaneous articles that are needful in the dispensary and ward. The purpose of the regimental hospital in field service is to furnish protection and care to the sick of the command while on a march or in the field, or to those temporarily sick in camps of instruction. It is an emergency hospital in the one case and a detention hospital in the other, but is not intended for the treatment of seriously ill patients who, in the event of a move, would prove to be an incumbrance to the regiment. When such cases are found they are to be transferred promptly to some hospital less exposed to the vicissitudes of war. But in certain cases when regiments are isolated, or when the sick cannot be sent to another hospital, the regimental hospital may be expanded to meet the necessities of the case.

But when troops are aggregated in large camps for war purposes the regiments are brigaded and the brigades organized into divisions and corps to facilitate the co-ordination of their movements in active service. The general commanding cannot handle a large army by regiments, nor can the chief surgeon of such an army have a competent field hospital organization on a regimental basis. On this basis there are as many small hospitals as there are regiments. But these regiments are in camp for field service, and as soon as the orders to march are published, the inaptitude of their hospitals to meet the new conditions becomes manifest. Military policy dictates that a column of troops on the march should be a column of fighting men, unbroken, at regimental intervals, by ambulances carrying sick men and by wagons with medical or other supplies. The ambulances with the sick are, therefore, aggregated into a single train, with position in rear of the last regiment, forming practically a general ambulant hospital for the command. The wagons containing the tents and hospital stores form part of the general supply train, which follows the command under the protection of the rear guard. On arriving at the site selected as the camp ground for the night, the ambulances which have travelled as an aggregate hospital during the day become separated into their regimental elements, each camping in the vicinity of its own command; and as the regiments may be widely scattered, many of them at considerable distances from the direct line of march, the day's march for the sick men may be thus needlessly lengthened. The troops, who carry their shelter tents and rations with them, are able to make themselves comfortable as soon as the camping ground is reached, but the hospital attendants must await the arrival of the rear guard and the wagon train before they can place the tired and suffering sick under shelter and refresh them with appropriate nourishment. Delays of this kind are especially frequent in wet and inclement weather, when the condition of the roads impedes the progress of the supply train.

But it is chiefly during and after a battle that the incompetency of the regimental system of hospital organization is manifested. The hospitals are scattered at various distances from one another along the rear of the line held by the troops. They are inconspicuous, and not easily reached by such wounded as come rearward without assistance or guide. No satisfactory supervision can be exercised over them. Some of the regiments suffer more than others. Their ambulances and stretcher bearers are unable to remove the wounded with promptitude from their exposed position in the field. The medical officers are overworked yet cannot accomplish all that should be done. Their hospital shelters are insufficient, and their supplies perhaps inadequate. Meanwhile the medical officers of those regiments that have not become engaged, or have not suffered severely, are at their posts awaiting developments on the line of battle. If there seems to be no prospect of an immediate call to action, these officers may assist their overworked comrades; but they may show some hesitancy in sharing their stores and dressings with others if there is a likelihood of their own commands becoming engaged before opportunity is afforded for replenishing these at a purveying depot. In fact, a regiment may at any time have more wounded men than can be provided for within the limits of a regimental hospital.

If a brigade of two or three regiments is operating as an independent command, a brigade field hospital is established by consolidating the medical and hospital equipment of the regiments. When the line of march is taken up the ambulances and transport wagons of the hospital follow in rear of the marching column. Two medical officers are placed on duty with this ambulant hospital, while the others remain with their respective regiments to give care to new cases until their transfer to the hospital is effected. This brigade hospital is not broken up into its regimental elements on reaching camp, but preserves its organization under canvas as on the march. In the event of an encounter with the enemy the hospital staff is strengthened. Standing orders in this event prescribe the special duties of every medical officer of the command. These are issued on the recommendation of the brigade surgeon. One surgeon is assigned to duty as the operator for the command. Three

contingencies probable during their absence, or without an order from superior authority, which is equivalent to such knowledge. Usually the wagon trains of the supply departments, after unloading at the front, may be secured for the removal of the wounded to the base or to railway communication with it, where accommodations for their treatment or special means of transportation to other points have been provided. If more wagons are required than have been furnished by the departments, an effort should be made to obtain them by further issues to the troops.

If the division is operating as an independent command the hospital follows the rear of the marching column; but if it is a part of a larger command, the order of march may direct a temporary partition of the hospital train. It may be imperative, from the military point of view, to have the various divisions of the army well closed up and unbroken by baggage or other heavy wagons. The ambulances are then permitted to follow in the immediate rear of the command to which they belong; while the heavier transport wagons of the hospital fall into position with the regimental baggage, ordnance, subsistence, and forage wagons, in rear of the whole fighting force except the rear guard, or the command specially detailed for their protection. In this column the hospital wagons are generally accorded the lead. One of the ambulance officers is assigned to duty with the portion of the train thus detached. This separation is usually temporary, the completion of the day's march bringing the wagons into camp shortly after the troops and their ambulances have reached it, the time of their arrival depending on the length of the marching column and the character of the roads, the weather, etc. Occasionally, however, the conditions of the campaign may continue the detachment of these wagons for a longer period.

On the march the ambulances constitute the division field hospital. Following in rear of the troops, it picks up those who have fallen out of the column from accident or the development of disease. Usually each of these men has been examined by his regimental medical officer and furnished with a card of authorization to await the passage of the ambulances. One of the officers on duty with the ambulances receives the cards, admits the patients, and procures such articles as may be needful for their immediate treatment. This admission by card is needful to save the energies of the hospital surgeons and preserve the ambulance transportation for the more urgent cases. The regimental officer knows the men of his command, and can arrive at an accurate estimation of the conditions in a given case in less time than the hospital surgeons, who have no previous knowledge, and who must conduct their examinations while on the move. If the troops are raw and undisciplined, men may drop out of the ranks in large numbers without the sanction of the regimental surgeons, and besiege the ambulances for admission. There is no time, while being pushed forward by the troops in rear, to make a discriminating examination, and these applicants are permitted to enter the ambulances. At the next halt for rest a few of the unwarranted entries may be weeded out, if the time of the officers is not wholly occupied in examining other candidates for admission; but ultimately, if the march is long, the roads bad, or the weather oppressive, every seat is in use, and the surgeons are importuned for the accommodation which they can furnish only by discriminating between one fagged-out man and another. The preliminary examination by the regimental surgeon, and admission to hospital on his authority, prevent this strain on the energies of the ambulant hospital.

The march has its sufferers as well as the battlefield, and these must be carried along and cared for; but simple exhaustion must be met by the general principle of halting the column at intervals for rest. If the military necessity requires a forced march, the commanding general must accept the loss of men which his line will suffer as the price of the position which he secures. The ambulances are an hospital, not a means of transportation for a jaded army. The sick and injured are to be carried, not the merely exhausted, who by a short period of rest will be recruited and enabled to push forward to the end of their march.

At the conclusion of the day's journey, when not immediately in front of the enemy, the hospital camps in some suitable place in rear and not distant from the command. While awaiting the arrival of the baggage wagons the sick are examined and treated. Such as are considered fit for duty are directed to report to their regiments. A notification should be sent to regimental surgeons in the cases of men admitted during the march without their knowledge, and retained as unfit for duty at its conclusion, that these men may be accounted for on the regimental reports. In the mean time the surgeon in charge indicates to the hospital attendants who have been detailed as pioneers the position which he desires the tents to occupy. Wood and water are procured, and the kitchen, and such other fires as the season and climate may require, are lighted in front of the position to be occupied by the tents.

On the arrival of the heavy wagons, the pioneers unload and pitch as much of the hospital canvas as may be required for the accommodation of the sick, and subsequently the tents of the officers. The nurses unload and fit into the raised canvas such cots, bedding, and other articles as may be necessary, and thereafter the litter bearers transfer the sick from the ambulance wagons.

The cooks obtain their kitchen utensils, and furnish tea and coffee by the time the sick are in their cots. Later in the evening dinner is prepared. Pending the preparation of this meal the ambulances and wagons are parked in rear of the tents and the horses fed, watered, and groomed, while the litter bearers pitch their shelters between the wagon park and the hospital tents, and the pioneers trench around the wards to keep their floors dry in case of possible rain. When rain is probable the tent ropes should be relaxed, lest their contraction dislodge the pegs and endanger the stability of the canvas.

In the establishment of camp each man, by drill and experience, knows his particular duty, and, by doing it heartily, the whole is accomplished with ease and rapidity. Less than an hour suffices to transform a deserted field into an hospital settlement as orderly and perfect in its appointments as if it had existed there for weeks. With dinner the labors of the day are at an end, save for the camp guard over the wagons and horses, the hospital guard, and the special work of the doctor and nurse in particular cases.

Under certain conditions it is better to make the sick pass the night in the ambulance wagons than to pitch canvas for their shelter. Thus, when the camp ground is reached late at night and an early start is anticipated, if the evening is wet and discomfort would attend the transfer of the sick to the tents, or even if the roads are miry and it is undesirable to have the hospital canvas made so much heavier by the rain, the patients may be made to pass the night in the ambulances, these vehicles thus constituting the division field hospital in camp, as well as on the march. Under such conditions, if the number of sick is larger than can be accommodated in the ambulances, tents may be pitched for the slighter cases, while those of a more serious character remain undisturbed under the ambulance covers.

When *reveille* is sounded, the teamsters groom, feed, and water their horses or mules, the litter bearers pack up their blankets and shelters, and fill the ambulance kegs with fresh water; breakfast is eaten; the sick are examined, and medicines prescribed and provided for their use during the day, after which they are transferred to the ambulances, while their recent quarters and bedding are packed up and placed in the wagons, which have by this time reported for their loads. When the troops fall in, the ambulances are in line, ready to move off in rear of their command; but the transport wagons remain in camp until all the troops have passed, and then join the column of the supply train. Thus another day's march is commenced.

leadership as foragers. During inclement weather these slighter cases may be housed in the hospital tents until their special camp is prepared. When thus systematically camped, the wants of the wounded are not likely to be overlooked, as each ward-master has his duties aggregated and defined.

But in the mean time the ambulances arrive from the field, and the whole staff of the hospital becomes at once actively engaged. Should the news from the front indicate that the tents will be insufficient for the accommodation of the wounded, the flies are removed and pitched as extensions of the wards, and the bedsacks filled with such suitable material as may have been collected in the neighborhood. If the extension of the wards by means of the flies is insufficient for the shelter of the incoming wounded, recourse may be had to the accommodation offered by the neighboring dwelling or its outhouses; but with the hospital establishment organized as stated, this will be needful only on exceptional occasions.

Should the enemy retire under pressure of the attack, it is not necessary for the hospital to follow the consequent advance of the command. The ambulances will have to make a longer journey to reach it; but it will be better for them and for the recently wounded to undertake this than for the whole establishment to make a forward move. Should the advance in pursuit carry the lines so far from the hospital as seriously to impair the usefulness of the latter, a forward move may be ordered, provided the wounded and sick can be carried in the ambulances and other wagons at the disposal of the surgeon in charge; but if the wounded cannot be thus transported, the orders should direct the hospital to be ready to move at a given hour, by which time all operations are expected to be performed and the wounded to be in condition to undertake a rearward journey in wagons specially provided for their transportation.

The surgeon in charge superintends the loading of these wagons, and provides for the comfort of the wounded by supplying the medical officer who is detailed from his regimental duties to accompany them with such articles of food and medicine as may be needful. He may have to part with some of his mattresses, bedsacks, and blankets in fitting out this train; but, if need be, a call may be made by telegraph to have them replaced from the purveying depot at the base of supplies.

Should the orders transmitted by the medical director require a forward movement of the hospital establishment, while no provision is made for the removal in the opposite direction of the wounded already accumulated, rations must be drawn from the general supply train and left with them, together with the necessary supply of medicines, stimulants, dressings, etc., required for the probable period of their stay and subsequent journey. Under these circumstances much of the hospital material may have to be left behind for the time being, under charge of an ambulance officer, with the wagons needful to insure its return to the hospital on the departure of the wounded to the base of supplies. The hospital may thus be temporarily disabled; but the greater its disability, the less is the likelihood of its being again called into serious action without time being afforded for recuperation; for the disability from this cause is proportioned to the loss inflicted on the command to which it is attached. If the command has suffered considerably, it will probably be placed in reserve for a few days, by which time the hospital material will have returned to the front.

But should a fiercely contested battle be fought, giving ten or twelve hundred wounded to each of the division hospitals, the lines become so broken and the troops so exhausted that time must elapse before either party is in condition for a renewal of the contest; ammunition, food, forage, and perhaps clothing wagons, have to be ordered up for use. The resumption of hostilities is a gradual process preceded by feints and manœuvres to develop the antagonist's strength, gain position, or await reinforcements. The existence of the hospital on the ground selected at the beginning of the battle may thus be prolonged, and ample time may be afforded the surgical staff for the completion of its labors; but the uncertainty which is inherent in all battlefield conditions renders it important that every effort should be made to have the wounded in condition for removal at the earliest possible moment. As soon, therefore, as the battle has ceased, certain medical officers who have hitherto been on duty at the front are directed to report to the surgeon in charge for assignment to temporary duty at the hospital, where the progress of the operative work is correspondingly hastened; or, the extra surgical help may be derived from the base or general hospitals, especially if telegraphic and railroad connections have been kept up. The aid required under these circumstances is skilled surgical assistance, to enable the hospital to complete its field operations. It is provided, as has been seen, with the needful shelters, supplies, and appliances for a large aggregation of wounded, and with the surgical aid requisite for the operative work, provided time is afforded in which to accomplish it; but as this important element is not always available, surgical aid from the front or rear is always of value.

Should the troops in the line of battle be driven back, and the hospital establishment become exposed, the surgeon in charge must take prompt measures to prevent its capture by the enemy. All the wounded who have been brought in should be removed, with the hospital material, to a suitable site in the rear of the position newly assumed by the troops. The wounded left upon the field must be cared for by the medical department of the opposing force, but such as have reached the shelters prepared by friends should not be given up without the strongest efforts on the part of those in charge to save them. If there is, unfortunately, no time to effect the removal of all, such as must be permitted to fall into the hands of the enemy should be left with as comfortable surroundings as if they were still within the lines. Hospital canvas, bedsteads and bedding, medical and surgical supplies, and food must be left with them, and such medical attendance as their number may require should be detailed to remain with and surrender them. Shelter and furniture thus lost to the hospital should be renewed by immediate requisition on the supply depots.

If the disaster is so serious that none of the wounded can be removed, the surgeon in charge should endeavor to preserve the hospital organization by withdrawing the ambulances, wagons, surplus stores, and personnel not specially detailed to remain with the wounded. When the hospital establishment is thus disabled, an immediate renewal of hostilities necessitates the occupation of the available buildings in the neighborhood of the new site; but this utilization of pre-existing shelter would have been necessary if, without the repulse, the wounded had by their number called for increased accommodation. The graver cases are received and bedded in the dwellings or their outhouses, and the slighter cases camp in their canvas shelters as before. Food, medicines, surgical appliances, etc., are furnished from the wagons which have been saved, and the operating staff is reorganized if it has suffered loss.

If the disaster involves the capture of the transportation and supplies, while more or less of the officers and men have escaped, to undertake the duty of aiding the wounded who may fall in the skirmishes of a subsequent retreat, a work is presented to these members of the hospital establishment which will be accomplished with an efficiency depending, *cæteris paribus*, on their previous discipline. Notwithstanding breaks in their ranks, their training holds them together as a machine constituted for a specific purpose. Wagons for the transport of the wounded, and of supplies obtained from the hospitals or purveying depots, may often be obtained from the army trains. The light headquarters' wagons were, on several occasions during our civil war, transferred to the hospitals, to form the nucleus of an extemporized ambulance system, and the work of collecting, treating, and providing for the wounded has thus gone on with more or less of precision and efficiency.

When the army goes into winter quarters, and occa-

department a free agent to sustain its great responsibility and gave it the Quartermaster's Department for collaboration and assistance. In this they were in advance of the methods of all other armies; but the Regulations issued one-third of a century later fettered the medical department with the bonds of slavery. The surgeon dropped to the status held by him in foreign armies as the mere attendant on the wounded when permitted by the officers of another department to come into personal contact with them. Even the medical director, a director in name only, was ordered to take his post for professional work at the principal depot.

The Regulations of 1861 found us engaged in a great war, with the army medical department responsible before public opinion for the care of the wounded, yet unable to accomplish anything without the consent and active cooperation of officers who were not held to this responsibility. Many of these officers were volunteers ignorant of their power under the Regulations, but all were actuated by the patriotic desire of accomplishing the end in view, of doing the best for the wounded under the conditions of the time. The medical work on the battlefields of the civil war progressed, therefore, under an intelligent appreciation of what the Regulations should have been rather than of what they were, and as a result, the excellent system of field hospitals and associated ambulance trains was developed.

Although at the close of the civil war the medical department of the army was trained into efficiency by its long experience, and although later, in 1887, it was strengthened by the formation of a trained hospital corps, wholly under its command, the conditions existing at the outbreak of the Spanish-American war in 1898 were most unfavorable for efficient service. At this time the medical staff and the hospital corps of the regular army were insufficient for the proper care of a command of twenty-five thousand men in time of peace. Suddenly the strength of the army, regular and volunteer, was raised to two hundred and eighty-five thousand men. Surgeons from civil life were appointed by the President as chief surgeons of corps, divisions, and brigades, and by the governors of States as regimental surgeons and assistants. Most of these officers were able surgeons and physicians, but few of them had had any experience of the duties pertaining to the medical department of a large army. Some had seen service in the national guards, but this was rather detrimental than otherwise, as it gave them an exaggerated idea of the importance of the regiment as a unit of organization. The law authorizing the muster in of volunteer troops provided for a surgeon and two assistants for each regiment, but there was no provision for any privates of the hospital corps. Transfers from the line of the volunteer army to the regular hospital corps were authorized, but the volunteer soldiers did not care to leave their comrades in the State regiments to accept service in the regular army; and, moreover, company and regimental officers did not look favorably upon such transfers. The medical department of the army was therefore met at the outset with the difficult task of raising and educating a hospital force of about five thousand men when it should have been organizing such a force for field service. As troops were being concentrated for an immediate invasion of Cuba and Porto Rico, instructions were issued looking to the organization of field hospitals and ambulance companies for divisions, by the consolidation of the regimental medical force and equipments. Great difficulty was experienced by chief surgeons of corps and divisions in effecting this organization, first, by the opposition of regimental medical and line officers to the breaking up of the regimental hospitals; second, the regulation allowance of one ambulance to each four hundred men and one four-horse wagon to each six hundred men of the effective force had to be built before being issued; and, third, the nine hundred hospital corps privates required to man the division hospitals and ambulance companies of each army corps had to be enlisted or transferred from the line before their services could become available. To perfect the field hospital organization of the army which invaded Porto Rico, the hospital personnel and equipment of commands remaining in the home camps had to be drawn upon, greatly to the detriment of the latter. Less difficulty was experienced in organizing the hospitals of the divisions of the Fifth Army Corps which invaded Cuba, as most of the regiments of this corps were regular regiments, each of which brought some hospital corps men and ambulances to the point of embarkation at Tampa, Fla. Long before the embarkation of this corps its field hospitals were in condition for efficient service, and although its ambulance companies were not filled up to their intended strength, nor fully equipped with wagons, horses, and harness, those sections which had their equipment completed were well drilled in hospital corps work and ready for active service. Each hospital had about eight six-mule wagons to haul its tentage and supplies. Operating tents were provided with enamelled-steel folding operating tables, steam sterilizers and water heaters, bath tubs, and other necessary furnishings. Subsequent events, however, rendered these preparations comparatively valueless. When the command embarked on the transports, the baggage wagons and mules, the ambulances and horses, and a large part of the equipment of each of the hospitals were left behind by order of the military authorities, to be forwarded after the troops on later transports. With the exception of a few ambulances, none of this medical provision thus left behind succeeded in reaching the army investing Santiago de Cuba. Even the small regimental medical and surgical chests were not available at the time the enemy was encountered because the transports, in accordance with military orders, stood out to sea after landing the troops. The medical officers of the command recognizing the impossibility, under existing orders, of giving any systematic aid to the wounded of a probable engagement, made the most strenuous efforts to recover some of their hospital supplies and equipment from the transports, and had such articles as they succeeded in obtaining carried by hand litters from the landing place toward the front. In this way a part of the equipment of the division hospitals was landed and utilized at the front as a field hospital and at Siboney as the nucleus of a base hospital. The tents of the reserve divisional hospital were landed to increase the shelter at Siboney, while the operating equipment and stores were retained on one of the transports, the *Olivette*, to outfit her as a hospital ship. The medical department of the army was severely criticised at the time of the attack on Santiago for its failure to have on hand all the material and equipment of its division hospitals in rear of the firing line of the divisions engaged; but this failure was in no part due to the carelessness or inefficiency of medical officers. The responsibility lay with the military authority which ordered and superintended the embarkation at Tampa, the landing at Daiquiri, and the immediate advance on Santiago. Military necessity may require an assault before the medical stores are on the ground, but the medical department is no more responsible for the consequent failure to have every comfort provided for the wounded than it is for the number killed and disabled in the attack.

Meanwhile in the home camps, the camps in the United States, the condition of the division hospitals became changed to meet changed conditions among the troops. The sudden ending of the campaigns in Cuba and Porto Rico rendered further preparation for battlefield service unnecessary. The division hospitals were therefore fitted up as stationary hospitals for the care of the sick. Regimental medical officers were returned to their regiments, while acting assistant surgeons were assigned to duty in the wards; trained female nurses were employed on contract; tent wards were framed, floored, and furnished with many articles of comfort which could not be carried with a field hospital in the presence of an enemy. In the camps regimental hospitals of ten beds each were established for the treatment of slight ailments until cured, and for the care of serious cases until their

transfer to the division hospital was effected. This system was continued until the return of the volunteer regiments to their homes for muster out.

The troops forming the army of occupation in Cuba and Porto Rico were distributed at various military stations, at each of which a post hospital was organized as in the medical service of the army in the United States in times of peace.

In the Philippine Islands a field-hospital organization based on that of the civil war was organized as soon as the men and materials were landed from the transports. The delay involved in accumulating near Manila a military force sufficient for a successful attack on the city gave time for the medical department to have its supplies available and its hospital corps men efficient. The wounded in the engagement were comfortably provided for by 7 P.M. of the day of the advance on Manila. After the occupation of the city, regimental hospitals were established near the quarters of each regiment, while the field-hospital equipment was utilized as the nucleus of what became afterward a large general hospital.

During the subsequent insurrection, lightly equipped field hospitals followed the troops to care for the wounded and put them in pròper condition for transportation by rail to Manila. Later, when the advance reached San Fernando, a field division hospital was established at that place, to which the wounded from the columns pursuing the enemy were brought by rail. Later still, when the troops moved in comparatively small commands after detached bodies of the insurgents, small field hospitals accompanied the expeditionary forces to bring the wounded back to San Fernando, or to the station on the railway constituting a temporary base. Ambulances sent from the United States proved to be too heavy for the soft muddy roads in the field of operations. Recourse was therefore had to light native wagons, carromatas, and to litters carried by hired coolies, with an intelligent hospital corps man in charge of each litter. Our medical officers were prompt to adapt their methods to the conditions confronting them and the facilities at command.

In the armies of all civilized nations special provision is now made for the care of the sick during campaigns, for the prompt removal of the wounded from the battlefield, and for their transportation with despatch and in comfort to well-appointed hospitals distant from the field of hostile operations. This provision includes field hospitals, with litter bearers and ambulances operating between the hospitals and the front. The establishment of collecting stations and ambulance stations is required by Regulations, the former at some sheltered point near the fighting line, the latter in a more distant and less exposed position. Battlefield conditions vary exceedingly, chiefly owing to topographical features. Hence no regulation distance between these establishments can be adhered to. In some armies four men of each company of the line are trained as litter bearers, to aid the wounded of their own company or regiment to the collecting or first-aid stations, where they transfer them to the care of the hospital corps. In other armies the bearer companies of the hospital corps are responsible for the care and transportation of the wounded from the front to the ambulance stations, to the exclusion of all assistance from the men engaged with the enemy. In reading accounts of medical organization for battlefield service a distinction must be made between the terms *company bearers* and *bearer companies*. The former applies to the few men in the fighting line of each company who are detached as temporary aids to the medical department, the latter to the men of the hospital corps who have been specially trained for this very purpose. There is no question as to which is the better method. To detach a percentage of the fighting force for hospital corps duty at a time when the whole strength of the line of battle may be required against the enemy is a dangerously expensive way of providing the medical department with the necessary number of litter bearers.

The field medical service of the German army was perfected during the war of 1870. Its regimental service is well defined, consisting of two medical officers to each battalion of about one thousand men, with a hospital assistant and two company bearers for each company and a medical supply wagon for each regiment of three battalions. Their field of duty in battle is between the skirmish line and the collecting stations. Besides the special aid on the fighting line the Germans have a bearer company of about two hundred and fifty men to each division and a similar company as a reserve to each corps. To thirty-six thousand troops forming a corps of two divisions they have, therefore, about seven hundred and fifty men for bearer duty; but the field hospitals of the corps are manned by about six hundred enlisted men, so that, exclusive of company bearers loaned from the line, the strength of the hospital corps on the field is equal to 3.75 per cent. of the fighting force. Each bearer company has attached to it eight ambulance and five store and baggage wagons. For each division six field hospitals are provided, each of which has a capacity of two hundred beds and may be divided into two sections. The enlisted force attached to each, including the drivers of eight or nine store and baggage wagons, consists of about fifty men.

In the French army there are, first, a regimental service to give aid to the troops in camp, on the march, and during an engagement; second, an ambulance hospital system to supplement the regimental service during marches and in camps, to receive the wounded from the battlefield and to prepare them for further transportation; and, third, a system of field hospitals to relieve the ambulance hospitals, to continue the preparation of the wounded for transportation to the rear, to treat the sick and wounded on the spot, and, occasionally, to reinforce the ambulance hospitals on the battlefield.

The regimental service consists of the medical staff with a hospital orderly for each company, a force of company bearers, and a wagon for the transportation of medical supplies. The bearers consist of a sergeant from the regiment, a corporal from each battalion, and four privates from each company. The hospital orderlies care for the sick when the command is on the march or in camp. During action they are at the collecting stations, to which the wounded are brought by the regimental bearers. When a battle is imminent the latter report to the surgeon for duty; after the action is over they return to the ranks.

The ambulance hospital of each division has a large medical staff, with thirty hospital orderlies and ninety-eight litter bearers, while the train is manned by two officers and eighty-eight men, sixty-four of whom are teamsters and the others orderlies, workmen, blacksmiths, saddlers, etc. This hospital is divided into two sections.

The field hospitals have no ambulances, their wheeled transportation consisting only of heavy wagons for supplies. The number of these hospitals attached to an army is determined by the Minister of War.

During the campaign against Napoleon the medical officers of the British army were well aware of the advantages accruing to the wounded from the methods introduced by Barons Larrey and Percy, and made many appeals to the government to be permitted to organize companies of ambulance corps men and litter bearers; but these were uniformly disapproved, as the Duke of Wellington objected to having the movements of his troops hampered by these wagons. Wounded Frenchmen were succored while the din of battle was yet in their ears, while their British opponents had to lie exposed, not only during the continuance of the struggle, but during the long watches of the night, until arrangements were perfected for their removal. The available wagons of the supply department and such as could be hired or impressed into service were brought up along with the bandmen, camp followers, and hired laborers to give the long-delayed aid and transport the sufferers to the hospitals. The stretchers used in loading consisted of a canvas bed between two pikes or poles, with no cross pieces to keep them apart. The long-continued wars of this period improved the organization and internal

economy of the British field hospitals, but effected no immediately beneficial change in their methods of transportation. Nor was anything done until the outbreak of the Crimean War, when a hospital conveyance corps was hastily organized and shipped with the troops. This was so decided a failure that the work of transporting the wounded had to be transferred to the subsistence department. The wagons of the conveyance corps were too heavy; no provision was made for repair in case of accidents; and the men were old, broken-down, and often dissipated soldiers weeded out of the regimental ranks rather than selected on account of special fitness for important duties. A medical staff corps was then organized, but this failed on account of its being composed of hired civilians. In 1873 a hospital corps of enlisted men was authorized. During the military operations of recent years in many parts of the empire, British medical officers have had opportunities of improving their methods, and have so profited by them that much commendation has been bestowed upon the army medical department for its efficiency during the war now in progress in South Africa. Sir William MacCormack and Mr. Frederick Treves, who were sent by the British government to the seat of war as consultants, have testified to the successful organization and efficient work of the department from the first-aid stations with the troops actually engaged to the general hospitals at the base of supplies. Officers, enlisted men, newspaper reporters, and, in fact, all who have written of this subject have borne testimony to the bravery and efficiency of medical officers and men and the abundance of their supplies. Lord Methuen, after the battle of Modder River, called attention to the splendid hospital arrangements, stating that on the afternoon of the day after the battle all his wounded were on their way to Cape Town.

An infantry division of the British army comprises two brigades, with three attached field batteries and a company of engineers. Each brigade consists of four battalions, or about four thousand men. Each battalion, artillery division, and engineer company has assigned to it a medical officer, who accompanies it into action with his orderly, to give first aid to the wounded, while the regimental bearers are ready to carry the first cases to the collecting or dressing stations.

To each brigade is attached one bearer company consisting of three officers, one sergeant-major, twelve sergeants and corporals, one bugler, and forty-four privates of the royal army medical corps, with thirty-eight men of the army service corps for transport duties. The men of the bearer company relieve the regimental bearers and bring the wounded to an advanced ambulance post, where there are wagons to carry them to the dressing station. This station is organized in some building out of the line of fire, or if no building is available the operating tent is pitched. The major of the bearer company, with one other medical officer, four non-commissioned officers, and four privates, one of whom is a cook, are on duty here, to examine and dress wounds, administer medical comforts, and place the wounded in ambulances to be carried to the field hospital.

Twelve field hospitals are attached to the corps of three divisions and attached troops, numbering in all about thirty-four thousand fighting men. Each is equipped for one hundred beds, but is so organized that sections of twenty-five beds may be unpacked and used separately. The personnel of each is four medical officers, one quartermaster, one sergeant-major, eleven sergeants and corporals, and twenty-three privates of the medical corps, with a sergeant and nineteen privates of the army service corps. As these hospitals have to accompany the troops, the wounded are sent as soon as possible to a post on the lines of communication. For service in the bearer companies and field hospitals an enlisted strength is provided equal to four per cent. of the fighting force. This percentage does not include the temporary services of the regimental bearers.

The lines of communication in the present campaign in South Africa are long. For the wounded who are unable to bear the fatigue of a long journey to the base of supplies, stationary hospitals have been provided along the line of rail. Each of these is equipped for one hundred beds in two sections of fifty beds. The personnel is similar to that of the field hospital, but without the army service men. Buildings are used when available, otherwise tents to form a camp are forwarded from the base.

General hospitals at the base of supplies have each accommodations for twenty officers and five hundred wounded men. Four of these were mobilized and sent with the first troops to Africa. Suitable buildings are selected. The staff of each consists of a colonel and seven officers, including a quartermaster, with eleven civilian surgeons, a woman superintendent and eight nursing sisters, two warrant officers, twenty-six sergeants and corporals, and one hundred and fifteen privates of the medical corps. Supplies of medical stores are established at the base and advanced depots are thrown forward to positions where the field hospitals and bearer companies can draw on them. Systematically equipped hospital trains bring the sick and wounded from the field and stationary hospitals to the base. Hospital steamers carry those invalided to England.

These brief sketches of the field-hospital organization of the German, French, and British armies, supplementing what has been said concerning our own experiences in this line of military service, will enable the reader to appreciate the great advance that has been made since the time of the Napoleonic wars. Field-hospital organization is now so well understood that with a medical and hospital corps of sufficient numerical strength for the needs of the command, with liberal appropriations for the purchase of equipment and supplies, and with full control over its transportation, there need be and would be no failure on the part of the medical department to care for the wounded under the most severe strain of the trying times of war. *Charles Smart.*

ARMY HOSPITAL CORPS.—For many years, during and after the revolution, the selection of the personnel of hospitals was left to the surgeons in charge. The stewards and ward masters, nurses and cooks were either detailed soldiers or civilians at the option of the surgeon.

The Army Regulations of 1821 for the first time distinctly provided that cooks and nurses in hospitals should be taken from the privates of the army, although such had doubtless been the usual practice before that date. During the civil war civilians, both men and women, were largely employed as nurses, especially in the general hospitals. They may also have been employed to a limited extent in the war with Mexico. With these exceptions, hospital attendants were obtained, from 1821 until the organization of the hospital corps in 1887, wholly by the detail of soldiers of the line, an arrangement which was always unsatisfactory, for it was difficult to secure the best men of the command for such duty, and the length of the detail being uncertain and promotion practically unknown, there was little to stimulate the ambition of the attendant.

The employment of civilians as hospital stewards for post and regiments, as well as for general hospitals, was still authorized in 1821; but as in the Indian wars which resulted from the spread of civilization westward, the activity of the army was transferred to the frontier, it no doubt became increasingly difficult to hire suitable civilians, while experience showed that it was desirable that the incumbent of this position should be amenable to military discipline and held to a definite term of service.

It therefore soon became the rule that hospital stewards should be detailed from the line, as is shown by the fact that in 1833 an order from the War Department gave authority for the enlistment of a hospital steward at posts where a suitable man could not be obtained from the command. But even though specially enlisted as hospital steward he was still mustered with a company

and regarded as a detailed soldier of the line, and in 1842 the adjutant-general decided that in case of emergency he could be required to perform military duty as such. Since the hospital steward could be returned to the line at any time at the caprice of the commanding officer, the necessity of securing for him a more permanent status was felt, and Congress in 1856 authorized the appointment of hospital stewards from the enlisted men of the army who should be permanently attached to the medical and hospital department. Commanding officers were, however, still permitted to detail, upon the recommendation of the medical officer, a soldier to act as hospital steward for field duty or at stations where there was no hospital steward. These men were at first known as acting hospital stewards. After 1864 they were called hospital stewards of the second class if detailed for duty at posts of more than four companies, and hospital stewards of the third class if at posts of four or less companies.

In 1862 the employment of civilians as cooks and nurses in the general hospitals having been authorized, the surgeon-general published regulations for the "Hospital Corps, U. S. Army," which was to be composed of civilians hired under contract for the period of one year, unless sooner discharged. Except in name this organization bears no resemblance to the present hospital corps, which was created by the act of Congress, March 1, 1887. This act required that hospital stewards should have served at least twelve months as acting hospital stewards, and have passed a satisfactory examination under the authority of the surgeon-general. It provided that privates of the hospital corps should be enlisted or transferred from the line, that acting hospital stewards should be appointed by the detail of suitable privates, and that the corps thus created should be permanently attached to the medical department, and should not be included in the effective strength of the army.

The number of men allowed in each grade was not fixed by this act. In 1896 the number of hospital stewards was limited by act of Congress to one hundred, which number constituted the allowance until the outbreak of the war with Spain, when an increase of one hundred hospital stewards was authorized for the war only. The number of hospital stewards was accordingly increased to two hundred, of whom one hundred and seventy still remained in service on March 31, 1900. By Act of Congress of May 26, 1900, the maximum allowance of hospital stewards was permanently fixed at two hundred.

There is no definite allowance of acting hospital stewards and privates, their number being regulated solely by the needs of the service.

The size of the hospital corps and the ratio of non-commissioned officers to privates will depend not only upon the actual size of the army, but upon the conditions existing at the time as respects active operations and the size of the commands in which the army is divided.

The high percentage of non-commissioned officers before the war with Spain was due to the large number of small posts, each of which was provided with a hospital steward, but required only a small detachment of privates. That the relative number of non-commissioned officers is less at the present time is due partly to the large number of privates stationed at general hospitals, at which the number of non-commissioned officers needed is comparatively small, and partly to the difficulty of securing a sufficient number of acting hospital stewards and the limitation by law of the number of hospital stewards.

For an army in active service or under the conditions which obtained in the Philippines, an allowance of hospital corps men, including non-commissioned officers, of at least four per cent. of the combatant strength is necessary. The chief surgeon of the Department of the Pacific (Philippine Islands) has estimated that acting hospital stewards in the proportion of one-half of one per cent. and privates in the proportion of three and one-half per cent. of the strength of the army should be provided for his department. Hospital stewards are not included in this estimate.

Army Regulations provide that there shall be a hospital steward and three privates of the hospital corps at every military post, four privates if the garrison consists of two companies, and an additional private for each additional two companies. If the garrison consists of six companies, there will be two hospital stewards and an additional hospital steward for every additional six companies. At every post of two companies there will also be an acting hospital steward.

The needs of foreign service have made it necessary of late to diminish this allowance of non-commissioned officers at posts within the United States. In view of the increased size of the companies at the present time, the Secretary of War has authorized an allowance of four privates of the hospital corps for one-company posts, five for two-company posts, and one additional private for every two additional companies. In the Volunteers, as at present organized, each regiment has three hospital stewards who are regimental non-commissioned officers. There being no provision of law for a Volunteer hospital corps, one acting hospital steward and twelve privates of the hospital corps, all of whom belong to the regular army, are assigned to each regiment. Regular regiments serving without the United States are allowed one hospital steward, three acting hospital stewards, and twelve privates. On March 31, 1898, there were in service 100 hospital stewards, 103 acting hospital stewards, and 520 privates, a total of 723 men. The following table shows the strength and the distribution of the hospital corps on March 31, 1900:

STRENGTH AND DISTRIBUTION OF THE HOSPITAL CORPS, MARCH 31, 1900.

	Hospital stewards.	Acting hospital stewards.	Privates.	Total.
United States	92	110	1,005	1,207
Cuba	21	47	327	395
Porto Rico	4	19	93	116
Hawaii	2	3	22	27
Philippines and en route	47 *	167	1,934	2,148
Atlantic transports	..	8	15	148
Pacific transports	..	8	25	
Hospital ships	4	7	81	
Total strength	170	369	3,502	4,041

* Seventy-four hospital stewards of Volunteers are also on duty in the Philippines.

The hospital steward is of the same grade of rank as ordnance sergeants, post quartermaster sergeants, chief musicians, principal musicians, first-class sergeants of the signal corps, chief trumpeters and saddler sergeants, and is only ranked among non-commissioned officers by the regimental sergeants major and quartermaster sergeants.

The duties of hospital stewards, as defined in the manual for the medical department, are to look after and distribute hospital stores and supplies, care for hospital property, compound and administer medicine, supervise the preparation and serving of food, maintain discipline in hospitals, watch over their general police, prepare reports and returns, supervise the duties of members of the hospital corps in the hospital and in the field, and perform such other duties as may by proper authority be required of them.

No other non-commissioned officer requires so much special knowledge for the proper discharge of his duties, or has such a variety of duties to perform, as the hospital steward. Like the first sergeant of a company the hospital steward must be a good disciplinarian, drill master, and general supervisor of the duties of the men under his control. He prepares or supervises the preparation of the numerous reports, returns, and other official papers, some of them voluminous and complicated, which must be made not only to the surgeon-general, but to the adjutant-general, the quartermaster-general, the chief of

ordnance, and the paymaster-general, and keeps a record of official correspondence. He must be unwearying in his care for the multiplicity of articles embraced under the name of hospital property. He must be an expert pharmacist, and have sufficient knowledge of medicine and surgery to be able to act intelligently in emergencies in the absence of the surgeon.

It is very commonly supposed that skill in pharmacy is the essential qualification of the hospital steward, and pharmacists often confidently apply for appointment as hospital stewards, referring to their knowledge of drugs as evidence of their fitness for the position. But such knowledge, while important, is by no means the most important requisite.

It is very wisely provided that the candidate for the position of hospital steward must have served at least three months as private of the hospital corps, and at least one year as acting hospital steward (the great majority of hospital stewards serve much longer than this in the lower grades), before he becomes eligible for examination for promotion, since familiarity not only with army regulations but also with the unwritten rules, usually known as the "customs and usages of the service," which should govern his conduct in his relations with superiors and inferiors in the military hierarchy, is absolutely essential to his usefulness, and such knowledge is to be acquired only by actual service with troops in garrison and in the field.

A candidate for the position of hospital steward, as has already been stated, must have served at least one year as acting hospital steward. Application for examination must be accompanied by an affidavit that the candidate is not married. Examination is held by a board of three medical officers or such number less than three as may be on duty at the post. The board investigates and reports upon the applicant's physical condition, character, and habits, especially as to the use of stimulants and narcotics, discipline and control of men, knowledge of regulations, nursing, dispensary work, clerical work, principles of cooking and mess management, hospital corps drill, minor surgery and first aid, including the extraction of teeth.

A written examination is also held, questions being prepared in the office of the surgeon-general upon the following subjects: arithmetic, materia medica, pharmacy, care of sick and ward management, minor surgery, and first aid and elementary hygiene. Efficiency in penmanship and orthography, which is also taken into account, is estimated from the papers submitted. Replies, which are certified to by the board as having been made without recourse to books, memoranda, or other sources of assistance, are forwarded with reports of the board direct to the surgeon-general, in whose office the written examinations are marked.

The candidate, if successful, takes rank in his class in accordance with the percentage which he has obtained on the examination. A re-examination before a first re-enlistment as hospital steward may not be required if the surgeon at the post, or chief surgeon of the department, states that the steward has performed his duties efficiently, but is held before a second re-enlistment. No subsequent re examination is ordinarily required.

Hospital stewards may be discharged by sentence of court martial, but cannot be reduced to the ranks.

As we have already seen, acting hospital stewards are historically the successors of the hospital stewards of the second and third class, also known as acting hospital stewards, who were soldiers of the line simply detailed for duty in the medical department. As the name implies, the acting hospital steward may be called upon to perform all of the duties of the hospital steward. Since the expansion of the army, due to the war with Spain, the insufficient number of hospital stewards has made it necessary to use many acting hospital stewards as stewards at the smaller posts. Before the late war, the acting stewards were generally assigned as assistant stewards in posts of two or more companies.

Owing to the unfortunate wording of the act of March 1, 1887, which speaks of the detail, not the appointment, of privates as acting hospital stewards, it was long held that the acting hospital steward is not a true non-commissioned officer, that his office is not a grade but a detail which lapses upon discharge, so that he then reverts to the status of private. Practically, however, he has always been regarded as a non-commissioned officer, and indeed is ranked with sergeants by Army Regulations, and a recent decision of the Comptroller of the Treasury grants him travel pay upon discharge and retired pay as an acting hospital steward, not as a private.

A service of one year as private in the hospital corps was formerly necessary before the examination for detail as acting hospital steward could be taken. This time was reduced to three months in 1899, because of the great need of additional acting hospital stewards, and the desire to utilize the services as acting hospital stewards of privates who had recently enlisted and who were to a certain extent qualified for the position by previous training in medicine, pharmacy, or nursing. The examination for detail as acting hospital steward embraces the same subjects as the hospital steward examination, but is less difficult. As in the case of hospital stewards, application for examination must be accompanied by an affidavit that the candidate is not married. Acting hospital stewards may be reduced to the grade of private of the hospital corps by the commanding officer for inefficiency or bad conduct.

In time of peace privates are obtained either by direct enlistment or by the voluntary transfer of enlisted men who have served at least a year in the line. Enlistments of civilians for the hospital corps are made preferably by medical officers. The term of service is three years. Authority for the transfer and enlistment is in all cases obtained from the surgeon-general. The physical examination for the hospital corps is the same as for the line, except that applicants may be accepted whose vision is below the normal, provided that the defect is due solely to comparatively slight errors of refraction (less than ten-twentieths), which are not progressive or accompanied by ocular disease, and which can be entirely corrected with glasses. As members of the hospital corps are not taught to shoot, acuity of vision is not as important for them as for men of the line, but it is essential that they shall be able to see sufficiently well not to be helpless if they lose their glasses in the field.

In addition to the physical examination, the applicant for admission to the hospital corps is required to give evidence that he can read and write, and that he possesses intelligence and aptitude for the duties which he will be called upon to perform. He must also present satisfactory testimonials as to his character from his late employer or other reputable citizens. After enlistment the recruit is usually sent to a hospital corps school, where he is given a course of instruction in nursing, first aid, etc., and in drill, preparatory to his assignment to a military post.

The duties which privates of the hospital corps are required to perform at military posts naturally vary somewhat with the size of the hospitals. At large hospitals, where the detachment consists of one hundred or more men, the duties of each man are narrowly defined and specialized. There are nurses, cooks, dispensers, clerks, operating-room, dead house, and laboratory attendants, watchmen, gardeners, even buglers, carpenters, plumbers, and perhaps painters. At the smallest posts there may be but a nurse, a cook, and an outside man who raises vegetables, milks, supplies fuel, and on occasion helps with the nursing.

Hospital stewards receive $45 per month, acting hospital stewards $25 per month, and privates $18 per month. The monthly pay is increased with the length of service, as shown in the subjoined table, $2 per month after five years' continuous service, and an additional increase of $1 per month for each subsequent period of five years. To be entitled to this increase the service must be continuous, that is, the soldier must re-enlist within three months after the date of discharge.

double-breasted, and with a detachable cape lined to conform in color with the facing on the uniform. The chevrons on the overcoat of the hospital steward and acting hospital steward are worn below the elbow with the point one-half inch above the cuff. The shoes are of russet leather. In the West Indies and the Philippines a blouse and trousers of brown cotton drilling or "khaki" are used instead of the woollen clothing. The brassard of the hospital steward and acting hospital steward chevrons are worn upon this blouse. Service chevrons are not worn. The arm of the service is denoted by shoulder straps of emerald green.

FIG. 277.—Uniform for Ward Service.

The equipment for field service of privates consists of the litter sling, canteen and strap, haversack and strap, with meat can, tin cup, knife, fork, spoon, and hospital corps pouch; when serving as orderly a medical officer's orderly pouch instead of the hospital corps pouch. The field equipment for non-commissioned officers is the same as for privates with the omission of the litter sling and hospital corps pouch. The following articles are contained in the orderly and hospital corps pouches.

CONTENTS OF ORDERLY POUCH.

Ammoniæ spiritus aromaticus in flask with cup........c.c.	60	Ligatures, catgut, sterilized, three sizes..............pkgs.	6
Bandages, gauze, sterilized. No.	6	Ligatures, silk, sterilized, three sizes.............pkgs.	6
Case, pocket ....No.	1	Mist. chloroformi et opii, in case, fluid or tablets......c.c.	30
Chloroform in case ....gm.	100	Pins, common and safety, of each ....paper	1
Catheter, Eng., rubber, in box.....................No.	1	Rubber bandage...........No.	1
Diagnosis tags and pencil book	1	Scissors....................No.	1
First-aid packets..........No.	4	Splints, wire gauze for, in roll.......................No.	1
Gauze, sublimated, 1-metre pieces.... ... .No.	4	Surgical plaster..........spool	1
Jacknife with saw blade, No.	1	Syringe, hypodermic ......No.	1

CONTENTS OF HOSPITAL CORPS POUCH.

Ammoniæ spiritus aromaticus in flask with cup... .....c.c.	60	First-aid packets...........No.	6
Bandages, gauze, sterilized, No.	6	Jacknife and saw blade....No.	1
Case, containing pins, common and safety, scissors and dressing forceps ....No.	1	Rubber bandage...........No.	1
		Splints, wire gauze for, in roll ....yd.	1
		Surgical plaster..........spool	1

No side arms are worn, but revolvers or other available firearms may be carried when serving in the field during Indian wars, or when the rights of the hospital corps as non-combatants under the Geneva convention will not be recognized.

When on active service, the clothing of each man is rolled up in the shelter tent supplied to him and the roll is secured by straps. It is ordinarily carried in a wagon, but can be made fast behind the saddle when the man is mounted.

Blanket bags, or knapsacks, such as are used by the infantry, were formerly carried by the privates of the hospital corps. Their use has been given up for the reason that they could not be used by men on mounted service, and that when on foot the hospital corps private must be unencumbered by heavy weights because liable to be called upon at any time to render aid to the sick or wounded.

The moral and mental qualifications of the candidate for transfer from the line to the hospital corps are or should be known in advance by the medical officer. He should investigate personally in making the selection of men for transfer, for many company commanders oppose the transfer of good men on the ground that they cannot be spared, and are on the other hand not unwilling to rid themselves of men who have shown themselves unable or unwilling to learn or are otherwise objectionable. The hospital corps is a picked corps. Its members have higher responsibilities than privates of the line and are properly given higher pay. There is a danger that men will be attracted by the pay alone or by the notion that the work of the hospital corps private is easier than that which falls to the private of the line. The hospital corps private has, it is true, no guard duty to perform and when no severe sickness prevails is not hard worked. On the other hand, he is always on duty, and his care of the sick may involve protracted watching and much disagreeable and possibly dangerous work, to perform which in the proper spirit he should have a real love for his calling.

The transferred man of the line is well disciplined, familiar with the conditions of army life, and at home in field service. Good gardeners and clerks and handy men for out-of-door work are easily obtained by transfer. To secure good cooks in this way is not so easy. They are treasures with which the officers of the line are reluctant to part. On the other hand, men enlisted from civil life are generally better educated and are more apt to be attracted to the hospital corps because of fondness for study, natural aptitude for nursing, or interest in medicine or pharmacy. Very few men excel in all the departments of the work which the hospital corps man is called upon to perform, and the most useful hospital corps detachment is not necessarily that one in which all the members are most highly educated. There will always be need of hewers of wood and drawers of water. At the same time while specialization is necessary, it is essential that all hospital corps men should have a knowledge of nursing and of first aid, including litter and ambulance drills.

FIG. 278.—Uniform for Field Service.

The Army Regulations provide that "members of the hospital corps will be instructed by a medical officer of the post for at least eight hours in each month. This instruction will consist of lectures and demonstrations in the methods of rendering first aid to the sick and wounded, and of drills in the ambulance service, and as litter bearers, in accordance with the drill regulations."

It was soon seen to be desirable that some of the soldiers of the line should participate in this instruction, and the Army Regulations of 1889 therefore directed that there should be four privates in each company designated for instruction as litter bearers. They were to be instructed at least four hours each month, together with all available men of the hospital corps, in the duties of litter bearers and the methods of rendering first aid to the sick and wounded, the object of this special instruction being defined to be "to insure the constant presence in each company of a number of men who can in emer-

gencies render temporary aid to the sick and wounded of their organization, and to constitute a reserve or school of instruction from which the privates of the hospital corps can be drawn."

The effect of the presence of the company litter bearers at the lectures was naturally to lead to special prominence being given to first aid in the instruction of the members of the hospital corps, and the subject was generally treated from the purely military standpoint. This course of lectures was supplemented by lectures to members of the hospital corps (at hours when they alone were expected to attend) upon nursing and such other subjects as come especially within their province.

The lectures were illustrated by the free use of charts, blackboard sketches, and microscopic preparations, as well as by practical demonstrations, and generally proved interesting to the men of the corps and the more intelligent of the company bearers.

In 1896 it was decided to extend the benefits of this instruction to all enlisted men. The company bearers were done away with and the regulations were amended to provide that all enlisted men of the army shall be instructed by their company officers, for at least four hours in each month, in the duties of litter bearers and the methods of rendering first aid to the sick and wounded. That the officers may be prepared for this duty, the surgeon of the post is required to instruct all company officers serving with troops in the professional knowledge required. This instruction will, it is directed, consist chiefly of practical demonstrations, utilizing for this the prescribed drills of the hospital corps, especial attention being given to the instruction in first aid. These practical demonstrations are to include methods of arresting hemorrhage, of applying the dressings contained in the first-aid packet, of immobilizing a fractured limb, of resuscitating those apparently drowned, etc., and are supplemented by lectures designed to convey all essential information with reference to the anatomy of bones and blood-vessels; the causes and treatment of syncope and of heat exhaustion; the differential diagnosis and treatment of sunstroke; the rationale of the various measures of first aid to the sick and wounded, etc. Except so far as it leads to better instruction of the officers of the line in first aid, the plan above mentioned, which is still in force, is regarded as of doubtful utility. Unless an officer is especially interested in surgery and medicine, he can hardly be expected to acquire a sufficient comprehension of first aid from a few lectures to enable him to give instruction which will be of much interest and value. In the present connection the regulation above cited is of interest inasmuch as it defines officially the scope of the lectures upon first aid.

In addition to the formal lectures to the hospital corps, much is done in imparting information at the bedside and in the operating room and the laboratory and the dead-house.

Each post hospital is supplied with a library of standard medical books and some current medical periodicals, which the studious and careful hospital corps men are permitted to use in their leisure hours. The intelligent man who makes good use of his opportunities for reading and observation can soon qualify himself for promotion, or if he does not desire to remain in the army will find that his term of service has been a valuable preparation for the study of medicine.

Such a course of instruction as the one above outlined is the only one possible at ordinary posts when the detachment is small and every man is constantly on duty. With fairly ambitious, intelligent, and well-educated men much can in time be accomplished by it. But there are manifest advantages in a more rapid attainment of proficiency in the knowledge necessary for the members of the hospital corps, and it is desirable that men enlisted from civil life should be subjected for a term to a rigid military drill and the strict discipline of a large detachment to beget the habit of prompt unquestioning obedience which is the first requisite of the soldier. In order to receive such military training it was at first provided that recruits for the hospital corps who had not had at least one year's service in the army should be attached for a year to a company stationed at one of several specified posts, and "be subject to all the drill and discipline required of privates in the organization to which they are attached."

This plan, which made no provision for instruction in the special duties of the hospital corps, was, however, soon given up, and in 1891 a hospital corps company was organized at Fort Riley, Kansas, on lines similar to that of companies of infantry with an allowance of eight non-commissioned officers (three hospital stewards and five acting hospital stewards). Soon afterward a second company of instruction was organized at Fort D. A. Russell, Wyoming. The Secretary of War authorized the transfer to these schools of men who had had only three months' service in the line. The time of the members of the hospital corps companies at these schools was fully occupied with drills, lectures, and various forms of practical instruction. The course was six months in length, but was extended to eight months in the case of men under instruction in pharmacy and clerical work. Very good results were obtained at these schools, but objection was made to their location on the ground of expense in matters of transportation, for the majority of the men who composed these companies were enlisted in the East, and after the completion of the course of instruction a considerable percentage were returned to the East again for duty. Accordingly the school at Fort D. A. Russell was given up in 1894 and a school was organized at Washington Barracks, District of Columbia. In 1896 the school at Fort Riley was also discontinued and the thirty privates there were distributed to several of the larger garrisons, generally those situated nearest to the headquarters of territorial departments, where they were given a course of instruction and kept as a reserve to fill vacancies in hospital corps detachments as they occurred. These posts are, with one exception, still authorized to maintain an increased number of hospital corps privates for the purpose above indicated, but the great demand for well-instructed men since the beginning of the war with Spain has made it impossible to leave privates under instruction for a sufficiently long period to obtain results of much value.

Systematic teaching in the hospital corps school of instruction at Washington Barracks was practically suspended during the war, not only because the time of the medical officers was so completely taken up by the care of the large number of patients in the general hospital which was established at that post as to leave them no opportunity for the giving of instruction, but also because the need of hospital corps men was so urgent in Cuba, Porto Rico, the Southern camps within the United States, and in the Philippine Islands, that time could not be spared for preliminary education. The school, therefore, became hardly more than a depot at which recruits were collected, uniformed, and sent to the front. With the return of more settled conditions the school was reorganized and expanded, and the course of systematic instruction was resumed. After the close of the war with Spain the large army collected in the Philippine Islands demanded extensive drafts of hospital corps men. Washington Barracks was selected as the rendezvous for recruits from the Eastern United States destined for that service, and a similar school was established at Angel Island at which hospital corps men enlisted in the West were collected and instructed before they were sent to Manila. The course of instruction in these schools was arranged with a view to especial preparation for Philippine service.

Since the conditions there have been such that women cannot live with safety at the interior posts, and since the number of small posts at which it would not be expedient to employ female nurses in any case is very large, it appeared especially necessary that members of the hospital corps should be familiar with the methods of preparation of food for the sick.

Instruction in cooking is therefore a prominent feature in the work of these schools. The immediate charge of

the courses is entrusted to female nurses, who have rendered excellent service.

The following is the course of dietetics as at present conducted at the Hospital Corps School of Instruction, Washington Barracks:

Liquid diet: milk, sterilized, albuminized, and peptonized, whey, junket, milk punch, gruels of oatmeal, farina, rice, hard bread, and arrowroot. Drinks: lemonade, orangeade, egg nog, lemonade sherry and egg, toast water, coffee, and tea. Broths: beef juice, beef tea bottled, beef tea with hydrochloric acid; beef, mutton, and chicken broth.

Light diet: canned soups, toast, oatmeal, farina, rice, rice flour, preparations of gelatin, lemon, coffee, and wine jellies; dried, canned, and fresh fruits; various modes of cooking eggs, potatoes, beef, and chicken.

Hospital stores: beef extract, malted milk, chocolate, arrowroot, and condensed milk.

The ration: field, travel, and emergency; modes of preparing hard bread, bacon, canned roast and salt beef, baked beans, peameal, and tomatoes.

The course comprises fifteen lessons of one hour each, and covers three weeks. The class is divided into squads of ten to eighteen men each, the number of squads varying with the strength of the command, and each squad is subdivided into sections of three or four men each for purposes of instruction. If more than fifty men are present, four squads are formed, and the hours are rotated according to the accompanying schedule, which also exhibits the general course of instruction.

Order of Exercises, Company of Instruction, Hospital Corps, Washington Barracks, D. C.

	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
6:30–7:15.	General police.......	General police.......	General police.......	General police.......	General police.	
7:25–7:40.	Setting up exercises.	Setting up exercises.	Setting up exercises .	Setting up exercises .	Setting up exercises.	General police.
8:00–9:00.	Cooking squad, 1 ...	Cooking squad, 4	Cooking squad, 3	Cooking squad, 2	Cooking squad, 1 ...	
	Drill squads, 2, 3, 4 ..	Drill squads, 1, 2, 3..	Drill squads, 1, 2, 4..	Drill squads, 1, 3, 4..	Drill squads, 2, 3, 4 ..	
9:15–10:15.	Cooking squad, 2 ..	Cooking squad, 1 . .	Cooking squad, 4	Cooking squad, 3	Cooking squad, 2	Inspection.
	Study squads, 1, 3, 4.	Study squads, 2, 3, 4 .	Study squads, 1, 2, 3.	Study squads, 1, 2, 4 .	Study squads, 1, 3, 4 .	
10:30–11:30.	Anatomy and first aid	Anatomy and first aid	Anatomy and first aid	Anatomy and first aid	Anatomy and first aid	Articles of war.
1:00–2:00.	Nursing and hygiene.	Nursing and hygiene.	Nursing and hygiene.	Nursing and hygiene.	Nursing and hygiene.	
2:15–3:15.	Cooking squad, 3	Cooking squad, 2	Cooking squad, 1	Cooking squad, 4 ...	Cooking squad, 3 ..	
	Study squads, 1, 2, 4.	Study squads, 1, 3, 4.	Study squads, 2, 3, 4.	Study squads, 1, 2, 3.	Study squads, 1, 2, 4 .	
3:30–4:30.	Cooking squad, 4	Cooking squad, 3	Cooking squad, 2	Cooking squad, 1	Cooking squad, 4	
	Study squads, 1, 2, 3.	Study squads, 1, 2, 4.	Study squads, 1, 3, 4.	Study squads, 2, 3, 4.	Study squads, 1, 2, 3..	

If the exigencies of the service permit, the recruit is retained at least one month at the school. During the first week he is given four hours of drill each day in the school of the soldier and in company drills and one half hour of "setting-up" drill, by which is meant a series of calisthenic exercises which are designed to keep the body supple and impart an erect and soldierly carriage. If the weather is inclement the hours which are designated for drills are devoted to elementary instruction in first aid. After the preliminary training the recruit begins the three-weeks course the schedule of which has already been given. To indicate the scope of the instruction in what is called in the table "anatomy and first aid" and "nursing and hygiene," a syllabus of the lectures recently given is appended. In such a brief course it is possible to deal with so wide a range of subjects only in the most elementary fashion, and it is much to be regretted that the conditions of the service have not permitted a longer period of instruction.

Lectures on "Anatomy and First Aid" and "Nursing and Hygiene."

Days.

1 Lesson 1.—Hospital corps pouch, orderly pouch, first-aid packet contents and uses.
Lesson 2.—Hospital ward, cleanliness and order, record books, property, ventilation, temperature, temperature charts.

2 Lesson 3.—Anatomy of the skeleton.
Lesson 4.—The patient, observation of symptoms, observance of surgeon's directions, feeding and bathing, administration of medicine.

3 Lesson 5.—Fractures and their treatment.
Lesson 6.—Disinfection and antiseptics, preparation of disinfectant and antiseptic solutions.

Days.

4 Lesson 7.—Joints and dislocations, methods of reducing dislocations.
Lesson 8.—Antiseptic treatment of wounds.

5 Review two hours.

6 Lesson 10.—Emergencies; sprains, frost-bites, and burns.
Lesson 11.—The circulatory system.

7 Lesson 12.—Emergencies; drowning, sunstroke, and heat exhaustion.
Lesson 13.—The circulatory system (concluded).

8 Lesson 14.—Hemorrhages and their treatment. The tourniquet.
Lesson 15.—The respiratory system.

9 Lesson 16.—General first aid. The triangular bandage.
Lesson 17.—The respiratory system (concluded).

10 Review two hours.

11 Lesson 19.—General first aid. Methods of carrying the wounded.
Lesson 20.—The alimentary system.

12 Lesson 21.—Contents of medical and surgical chests.
Lesson 22.—The alimentary system (concluded).

13 Lesson 23.—Contents of medical and surgical chests (concluded).
Lesson 24.—The fundamental bandages.

14 Lesson 25.—Contents of field operating case. Care and disinfection of instruments.
Lesson 26.—The fundamental bandages (concluded).

15 Review two hours.

In the strictest sense of the term a hospital corps school of instruction is an institution in which members of the hospital corps are received primarily as pupils, such practical work as they may do in connection with the sick being subsidiary, and to be regarded as a part of their education. The small post at which each member of the hospital corps detachment has his regular daily task and receives only an hour or more of systematic theoretical and practical teaching each week represents the other extreme as regards instruction. But between these two extremes are the large hospitals at which are collected a numerous body of hospital corps men who have well-defined hours of duty and of rest, so that a considerable detachment can be brought together for instruction every day. At such institutions much good work has been accomplished in the education of the members of the hospital corps. A school was established in the Second Army Corps in 1898 at Camp Alger and afterward at Augusta, Ga., at which about two hundred and fifty hospital corps men were trained and at the completion of their course given diplomas in due form at public graduation exercises. In the Seventh Army Corps the large hospital corps detachments at division hospitals were organized into companies of about sixty men each, and each company was given daily instruction in drill and in first aid when the number of sick permitted. When the hospital known as the United States Military Hospital No. 1, at Havana, was opened a large number of uninstructed recruits were received, the great majority of them entirely ignorant of their duties as members of the hospital corps and as soldiers. The chief surgeon directed the establishment of the school in connection with the hospital at which was given a course of discipline and instruction which resulted, to quote his words, "in giving us as soldierly, prompt, and well-disciplined a body of men as I have ever seen in the service," and in demonstrating that "the medical officers may take raw recruits and make them well-drilled and efficient soldiers as well as proficient in special duties of the hospital corps."

As showing what may be accomplished in the heat of a Cuban summer by a zealous and efficient medical offi-

cer, a more detailed report of the course of instruction is of interest.

In the period from June 15, 1899, to November 25, 1899, one hundred and forty-seven privates and seven acting hospital stewards were instructed in this school. Instruction was given to all who could be spared from the care of the sick by daily drills and lectures for five days in the week in detachment drill, litter drill, ambulance drill, first aid, ward work, care of animals, nursing, bandaging, cooking and sanitary methods, and tent drill. Also general instruction with a view to preparation for field service. Numerous lectures were given on nursing, especial stress being laid upon the preparation of the operator, patient, instruments, dressings, tables and room before an operation, asepsis and antisepsis being thoroughly explained, and on the treatment of hemorrhages, gunshot wounds, the nursing of typhoid fever, etc. The men were detailed to the wards in succession, and were thus enabled to put theory into practice. An especial feature was the tent drill. "In the tent drill the men became very proficient, pitching tents for a field hospital, putting up the beds, filling the bedsacks with hay, making the beds, putting in bedside tables and chairs, etc. The time occupied from the command 'Pitch hospital tents, march!' (the tentage being on wagons, and the men detailed as patients lying on the ground) until patients were in bed in the furnished tents,

2 P.M. to 3:30 P.M. .... Instruction in office.
4 P.M. to 5 P.M. .... Drill.
7 P.M. to 9:30 P.M. .... Study and quiz.

Notwithstanding the hard work done, the sick report of the hospital corps company was exceedingly low, being for considerable periods less than two per cent. of those present. A similar school has been under operation with excellent results at the Third Reserve Hospital at Manila.

The surgeon of this hospital reports as follows under date of December 23, 1899, as to the duties and the instruction of the hospital corps detachment:

"The present personnel of the institution consists of 4 officers, 4 non-commissioned officers, 40 privates, 263 patients, 8 native Tagalog laborers, and 7 Chinese laundrymen. The following are the departments with the number attached to each:

Baths and plumbing (1 pvt.).
Carpenter shop (1).
Dark room.
Dining service (8).
Dispensary (1 n.-c. o., 1 pvt.).
Library.
Linen and laundry (1 pvt., 7 Chinese).
Nurses (6).
Mail (1).
Office (1 n.-c. o., 2 pvts.)
Driver (1).
Filters and boilers (1).
Guard.
Kitchen (7).
Light diet service (2).
Orderlies (2).
Provost sergeant (1).
Stables (1).
Trumpeters.
Ward masters (5).

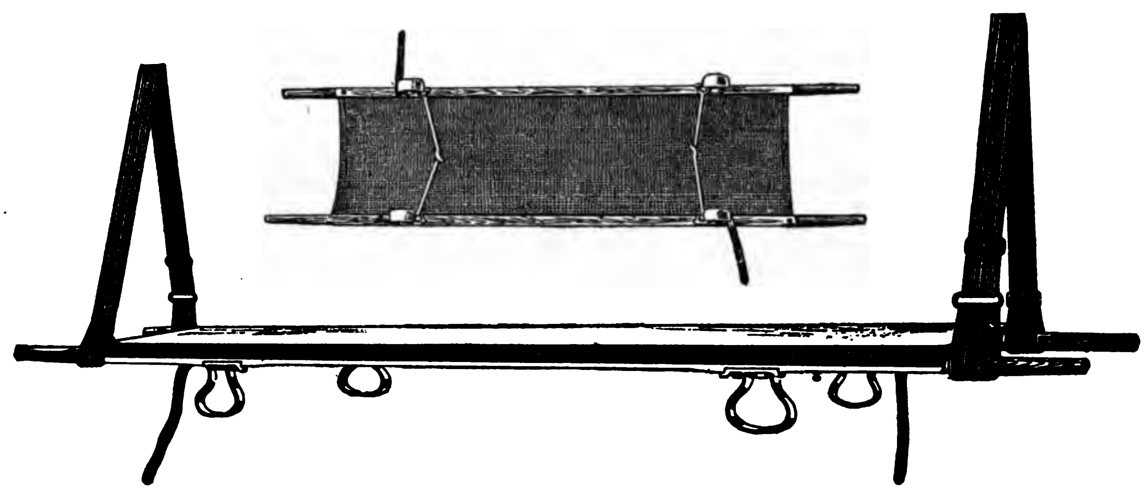


FIG. 279.—Hand Litter. (Model of 1899.)

being twenty minutes for the first tent, the others being completed almost immediately after, in quick succession, the time varying from twenty-one to twenty-six minutes; fires were made on the ground and several gallons of water were boiling in seventeen minutes from the time the command 'March!' was given and three minutes before the patients were in bed.

"At the command 'Strike tents, march!' the patients were very carefully carried out and laid upon the grass, the blankets folded, bedsacks emptied and folded, beds folded, tents struck and loaded on the wagons, the time occupied from the command 'March!' until the wagons were ready to drive off being fourteen minutes. In these drills the intervals between the tents were perfect, the tents perfectly erected, and the tent pegs, as well as the tents themselves, carefully aligned."

A school was also established for non-commissioned officers in which two hospital stewards, seven acting hospital stewards, and nine privates, all of whom subsequently passed the examination for detail as acting hospital steward, were instructed. The hours of instruction in this school were as follows:

7 A.M. to 8 A.M. and 9 to 10 A.M. ... Drill.
10 to 11:30 A.M. .... Instruction in dispensary.
1 P.M. to 2 P.M. .... Lecture.

"The duties of the four non-commissioned officers are as follows: 1. Superintendent of hospital; in charge of property. 2. In charge of office and records. 3. In charge of dispensary. 4. Commissary.

"In addition to its first, and always paramount object, the care of the sick, another important function of the hospital is the instruction of the enlisted men of the hospital corps. This is systematically carried on in four directions. The whole hospital is regarded as a school, and each department is put in charge of a soldier, who is held responsible for its condition. His orders are written in the plainest language, verbal ones being avoided as much as possible. At the end of each month an entire change takes place, so that by means of a regular rotation every man becomes acquainted with the working of the entire system. By this means no man is allowed to stagnate in one place to the detriment of his general efficiency as a sanitary soldier.

"Lectures, or more properly, informal didactic instruction, supplemented by questions and answers, are held five times weekly, the present course being as follows:

"Mondays—Discipline, regulations, and drill.
"Tuesdays—Minor surgery and first aid.
"Wednesdays—Nursing and ward management.

"Thursdays—Materia medica and practical dispensary work.

"Fridays—Clerical work, the ration and its management.

"This course is varied from time to time, as seems desirable, examinations are held, and men showing sufficient proficiency are recommended for promotion.

"Drill (foot, setting-up, and litter) is held five times a week, the hour being immediately after reveille. As a means of instilling discipline, as necessary physical exercise, and especially for the formation of the habit of instant and soldierly obedience, this portion of the instruction is considered indispensable, and no one is excused from it unless he be upon sick report. Regular roll calls are also considered necessary.

"The last form of instruction is not very tangible, but is of no small moment—the formation of an *esprit de corps* in the detachment. For this purpose the men are encouraged to form an association of their own, the squad room is furnished with electric lights and a score of periodicals, an interest is manifested in their baseball club and athletic sports, and the men are given to understand that their detachment is an organization well meriting pride in its soldierly efficiency."

The hospital corps private receives the same instruction in the elements of drill, such as facings, salutes, the setting-up exercises, etc., as other soldiers. The detachment drill without litters is essentially that of infantry without arms. The utility of such drill, so far as the hospital corps is concerned, is chiefly in the promotion of discipline and of a soldierly carriage.

The following is a description of the litter (model of 1899) as at present constructed (Fig. 279):

Side poles are of well-dressed, straight-grained ash, seven feet six inches long, one and one half inches wide, and two inches deep. The upper part of the outer surface of each pole at the attachment of the canvas is shaved away one-eighth of an inch. The surface of the applied canvas and of the heads of the nails attaching it is flush with the lower and unshaved part of the said surface. The ends of the poles are rounded into handles nine inches in length.

The canvas is of strong, twelve-ounce cotton duck, dyed fast dark brown, six feet two inches long by two feet two inches wide. At each end an inch is turned under and sewed down, and at each side an inch is turned under and tacked to the shaved surface of the side bar, so that the upper surface of the canvas is six feet by twenty-two inches in the clear.

The legs or feet, which are of malleable iron, stirrup shaped, raise the under surface of the poles four inches from the ground level. The pole plate of each leg is three and three eighths inches long, and has on the outer part of the end toward the mid-length of the pole, a projection to keep the braces in position when the poles are approximated. The plate is turned up at the sides one quarter of an inch to grasp the pole which is here countersunk, so that the metal is flush with its outer surface. The pole plate has two apertures; one, three eighths of an inch in diameter for the bolt on which the brace or traverse iron plays, the other, three-eighths of an inch in diameter between the blades of the stirrup for the bolt which secures the whole to the pole. The loop of the stirrup is one and three-quarters inches wide near the pole plate, widening out to three and five-eighths inches at its widest part, about three-quarters of an inch from the footplate. The blades forming the loop are each seven-eighths of an inch broad at the neck, expanding to one and seven-eighths inches where they conjoin to form the footplate, which is somewhat convex in every direction, to give a broad support.

The braces are of steel forging, each consisting of two pieces playing by their outer ends on the bolt in their respective pole plates and hinged by a bolt at the junction of their inner ends. Each piece is formed of a bar of steel forging one half an inch wide and five eighths of a inch deep. The outer end is flattened to facilitate movement on the pole plate. The inner end of one projects about one inch beyond that of the other, which it embraces, thus strengthening the joint when the braces are on the stretch, and this joint is fenestrated on the back to prevent choking by mud and dirt. The head of the bolt or pivot by which the brace is attached to pole plates is one inch in diameter and one-eighth of an inch thick. From the centre of this pole plate bolt to the centre of the rivet which hinges the pieces, each measures ten and a quarter inches, and the whole when on the stretch makes the litter twenty-two inches wide from outside to outside of the canvas-covered bars. When the litter is closed the braces project lengthwise toward the centre of the litter immediately beneath the approximated poles.

The fastening for the closed litter is provided by means of two leather straps, eleven inches long and three-quarters of an inch wide, one attached to the under surface of one pole, one inch toward the handle from the pole plate, the other to the corresponding part of the opposite end of the other pole. When the litter is open the strap is under the pole and fastened to a stud, but when the litter is closed the strap is passed around the two poles from its point of attachment on the one pole to a stud in the corresponding part of the other.

The weight of the litter is twenty pounds.

The regulation litter sling which is issued to each private of the hospital corps as a part of his equipment is made of blue webbing two and one half inches wide, with a leather-lined loop at each end, and a slide to regulate its length, so that it can be adjusted to the size of the individual to whom it is issued. During drill when not in use the sling is carried over the shoulders and the loops are secured under the belt; when the litter is to be lifted the loops are drawn from the belt and slipped over the handles of the litter.

In the drill with the open litter the litters may be marched by the usual commands given to infantry, substituting "litters" for "fours." Military situations can be imagined in which it would be of advantage that litters loaded with patients should be marched in line or in column, and in which it might be necessary to change the formation from line to column or the reverse; but in actual warfare the more complicated evolutions will almost never be needed.

The chief object of litter drill is to familiarize each of the four men who constitute the individual litter squad with his duties so that he can perform them without confusion or hesitation and to the best advantage of the patient. The drill is made as nearly as possible like service in actual warfare. Men are used as "dummy" patients. A diagnosis tag having been attached to their clothing to indicate the nature and location of the injury to be dressed, before loading, they are directed to take positions such as would be expected on the battlefield. At the command "Search for wounded!" each leader assumes charge of his squad and proceeds independently.

The members of the litter squad are numbered from one to four consecutively. The litter when closed is carried on the shoulder of No. 3, who acts as rear bearer of the open litter, No. 2 being the front bearer. The positions of Nos. 1 and 4 are opposite the centre of the litter on the right and left respectively. When approaching a patient, they run in advance of the litter, investigate the nature of the injury, and apply splints, check hemorrhage, or render such other service as the nature of the case may demand. When the patient has been placed upon the litter, they resume their positions opposite the centre of the litter. They relieve Nos. 2 and 3 as bearers when the latter are fatigued. The change of bearers may be effected, if necessary, without interrupting the march. No. 1 has command of the squad, whatever his position with respect to the litter may be.

While the loaded litter is usually carried by two bearers, when the ground is unusually difficult or when obstacles must be surmounted it is carried by all four of the bearers, one man at each handle. In ascending stairs or steep inclines the front bearer retains his hold

able that one bearer should attempt to carry a patient unaided, but emergencies may arise in which this is necessary. For short distances a patient may be carried in the arms of a strong man, or one that is conscious and able to help himself to a certain extent may be carried astride of the bearer's back.

For unconscious patients two methods may be employed: carrying across the back and across the shoulder. For the first method, the bearer, turning the patient on his face, steps astride of him, facing toward the head, and with hands in his armpits lifts him to his knees, then clasping hands over the abdomen, lifts him to his feet; he then with the left hand seizes the patient by the left wrist and drawing the left arm about his (the bearer's) neck holds it against his left chest, the patient's left side resting against his body, and supports him with his right arm about the waist.

The bearer with his left hand next seizes the right wrist of the patient and draws the arm over his head and down upon his left shoulder, then shifting himself in front, stoops and clasps the right thigh with his right arm passed between the legs, his right hand seizing the patient's right wrist; lastly, he, with his left hand, grasps the patient's left and steadies it against his side, when he rises (Fig. 281).

FIG. 282.—Patient across Shoulder.

In the second method, the patient being raised and supported in the erect position as in the first method, the bearer clasps his hands about the patient's waist, shifts himself to the front, facing him, and stooping places his right shoulder against the abdomen; he passes his right hand and arm between the thighs—securing the right thigh—and with his left grasps patient's right hand, bringing it from behind under his (bearer's) left armpit, when, the wrist being firmly grasped by his right hand, he rises (Fig. 282).

The first method is more comfortable for the patient, but the second method has the great advantage that the bearer's left hand is free so that he can descend a ladder. It is in fact a fireman's method, and is much better adapted for carrying a patient who is asphyxiated, but otherwise uninjured, than a wounded man.

The ambulance is a four-wheeled vehicle, which provides transportation for eight men sitting or for two recumbent. In some ambulances there are two tiers of litters so that four recumbent patients may be transported. In the more approved ambulances, the regulation litter is used, the litter upon which the patient was originally placed being pushed into the body of the vehicle from the rear. A variety of styles is now in use, and since a board is sitting at the time at which this article is written for the purpose of deciding what model shall be finally adopted, no attempt will be made to describe in detail the present vehicles.

For a full account of the drill of the hospital corps the reader is referred to the manual of drill entitled "Drill Regulations for the Hospital Corps, United States Army," edition of 1900.

The methods which are practically employed in the transportation of the wounded are described in the article upon that subject. *George E. Bushnell.*

ARMY MEDICAL DEPARTMENT.—Admission to the medical corps of the United States army is by competitive examination. Any medical graduate of a college in good standing may appear for examination, provided he is a citizen of the United States, between twenty-two and twenty-nine years of age, and of sound health and good character. He must present evidence that he has had at least one year's hospital experience or the equivalent of this in practice subsequent to his graduation. The applicant should write to the Secretary of War requesting authority to present himself before an examining board, giving the date and place of his birth and the place and State of which he is a permanent resident, and enclosing certificates as to his citizenship, character, and habits from at least two reputable persons. He will then be informed when and where the examination will probably take place. Examining boards are convened from time to time to fill vacancies as they occur. For some years before the Spanish-American war a board was in session annually in September and October, in the Army Medical Museum building at Washington, D. C., to fill the vacancies occasioned by deaths, retirements, or resignations during the year. Boards may, however, be convened in other cities. One has now (February, 1900) been appointed to meet in Manila, Philippine Islands, to afford an opportunity of entering the regular service to volunteer medical officers and physicians on contract now serving with troops in those islands. When a board is convened in the United States, due notice is published in the medical journals, and candidates whose applications are already on file in the War Department are notified by letter to report in person to the president of the board on a given date. The expenses of travel and other personal expenses incident to the period occupied by the examination must be borne by the candidate.

The physical examination comes first in order, and is as carefully made as if the candidates were applicants for enlistment in the ranks. Those who fall below sixty-four inches in height are rejected. Each candidate is required to certify that he labors under no mental or physical infirmity or disability which can interfere with the efficient discharge of any duty which he may be required to perform. Slight errors of refraction which can be corrected by glasses and which are unaccompanied by ocular disease do not cause rejection. The preliminary or mental examination is conducted by questions written and oral on arithmetic and physics, the history and geography of the United States, ancient and modern history, and general literature. Candidates claiming special knowledge of the higher mathematics, ancient or modern languages, drawing, analytical chemistry, or branches of the natural sciences are examined in these subjects as accomplishments and receive due credit according to their proficiency. The professional examination includes anatomy, physiology, chemistry, hygiene, pathology, and bacteriology, materia medica and therapeutics, surgery, practice of medicine, obstetrics and the diseases of women and children. Examinations are also conducted at the bedside in clinical medicine and surgery, and demonstrations and operations on the cadaver are required to be made by the candidates. At the conclusion of the examination, which lasts six or eight days, the merits of the candidates in each of the branches and their relative merit as determined by the results of the whole examination are reported by the board, and in accordance with this report the surgeon-general recommends the appointment of the successful candidates to fill existing vacancies. Those who fail at this examination may be allowed to appear again after one year, but no third trial is permitted.

Ordinarily the first duty required of the young medical officer is attendance at the army medical school during a session of five months, November to March, to fit him for his future duties and responsibilities. The school was organized in 1893 by Surgeon-General Sternberg. The faculty consists of: (1) A president who is responsible for the discipline of the school and who delivers a course of lectures upon the duties of medical officers in war and

peace, including the requirements of Army Regulations regarding property responsibilities, recruits, discharges for disability, sick reports, rights and privileges of officers and customs of the service; (2) a professor of military surgery who teaches operative surgery, the care and transportation of wounded in time of war, and the administration of hospitals; (3) a professor of military hygiene who gives practical instruction in the examination of air, water, food, and clothing from the sanitary point of view; (4) a professor of military medicine; (5) a professor of clinical and sanitary microscopy who gives laboratory instruction in bacteriological work, and (6) an instructor in hospital corps drill and company management.

After graduating at this school the young medical officer is assigned to duty at some military station. His rank, pay, and emoluments are those of a first lieutenant of cavalry for the first five years of his service and of a captain of cavalry for the remaining years of his service in the grade of assistant surgeon. In addition to the fixed pay of his rank he is entitled to an increase of ten per cent. for every completed period of five years' service until a maximum of forty per cent. has been reached. Thus the pay of a newly commissioned assistant surgeon is $1,600 per year, or $133.33 monthly. At the end of five years he is promoted to the rank of captain and receives $2,000 per year, but as he is entitled to a ten-per-cent. increase of this by virtue of his five years of service he receives $2,200 per annum, or $183.33 monthly. At the end of ten years the service percentage entitles him to $2,400 per annum and after five years more to $2,600. By this time deaths, resignations, and retirements among those above him will have brought him up toward the head of the list of assistant surgeons. On his promotion to the grade of surgeon with the rank of major, the pay of which rank is $2,500 per annum, he receives $3,250 if he has been fifteen years in the service and $3,500 if he has completed twenty years of service. The monthly pay of the lieutenant-colonel, colonel, and brigadier-general is respectively, $333.33, $375, and $458.33. These sums include the forty per cent. increase for length of service.

At the present time the medical corps consists of one surgeon general with the rank of brigadier-general, six assistant surgeons-general with the rank of colonel, ten deputy surgeons-general with the rank of lieutenant-colonel, fifty surgeons with the rank of major, and one hundred and twenty-five assistant surgeons with the rank of captain or lieutenant, according to their length of service. When an officer reaches the age of sixty-four years he passes from the active to the retired list, and each of those formerly below him on the active list gains a step upward in lineal rank toward the next grade. Retired pay is seventy-five per cent. of the pay received by officers of the same rank on the active list.

Medical officers in addition to their pay proper are furnished with an allowance of quarters according to rank either in kind or by commutation if there is no suitable government building available. When travelling on duty without troops an allowance of four cents per mile is provided, with reimbursement of money actually expended for railroad or other fare. In changing station, transportation is provided also for professional books and papers and for a reasonable allowance of baggage. Forage, stabling, and transportation for two horses are allowed to each officer. Groceries and other articles may be purchased from the subsistence department and fuel from the quartermaster's department at about cost price.

The hospital at every permanent military post is well provided with books, instruments, and apparatus for chemical and bacteriological work.

The stations of medical officers are changed every two or three years or according to the requirements of the service. The surgeon-general, in making assignments, considers the record of each officer so that no undue share of arduous duty or service at stations remote from the United States shall fall to any one officer.

Leave of absence on full pay is allowed at the rate of one month per year, and this when not taken during the year may be allowed to accumulate to a maximum of four months, which at the end of four or more years may be utilized as one continuous leave. Absence from duty on account of sickness does not involve loss of pay. Permanent disability incurred in the line of duty entitles an officer to be placed on the retired list.

Toward the end of his fifth year of service and prior to his promotion to the rank of captain the young medical officer is examined on his knowledge of Army Regulations, and the practical work, medical, surgical, sanitary, and official, involved in serving with troops. Again, when medical officers with the rank of captain approach the head of the list of officers of their grade they are usually assigned to duty as attending surgeons and examiners of recruits in the principal medical centres of the United States to enable them to become familiar with the practice of the leading physicians and surgeons and to attend medical lectures, meetings of medical societies, etc. These assignments are made for one year only in order that as many medical officers as possible may be enabled to avail themselves of the advantages thereby afforded. An examination follows to test their knowledge of the advances made in medicine and surgery during the years which have elapsed since their promotion to the rank of captain. Surgeons and officers of higher grade are not subjected to examination for promotion.

A brief *résumé* of the history of the army medical department finds an appropriate place in this article. The army of the Revolution had at first only regimental surgeons and their mates or assistants. The Provincial Congress of Massachusetts Bay required each candidate for a position in the medical department of the army to be subjected to a close examination by qualified medical men; and there was nothing *pro forma* in these examinations, for it is on record that no less than six of a set of fourteen were rejected on account of failure to come up to the standard. This system of examination for appointment has continued throughout the intervening years and is in force at the present time. After the fight at Breed's Hill a general hospital was established at Cambridge for the care of the wounded. Subsequently, general hospitals were established at Ticonderoga, N. Y., and at Williamsburg, Va. To provide these with the requisite medical officers, surgeons were appointed who belonged to no regiment, but to the hospital department in general as staff surgeons. This arrangement aroused a strong feeling on the part of the regimental surgeons, who protested against the removal of their sick and their reduction to the level of dispensary surgeons for the slighter ailments of camp. They claimed the right to take care of their own sick, and they were supported in this by a majority of the regimental and company officers. It is interesting to observe how mankind forgets its experiences. More than one hundred and twenty years afterward, during the Spanish-American war, the same clamor was raised by regimental surgeons of volunteers, their colonels and company officers, against the establishment of division hospitals and the necessary disestablishment of regimental hospitals as incompetent to meet the exigencies of active field service, although this incompetency had meanwhile been proved during the long years of the civil war.

To allay the jealousies between the two sets of officers, a bill was passed for the establishment of a medical department based on the organization of the British service. It provided for so many officers with high-sounding titles that General Washington is reported to have criticised the proposition thus: "The number of officers mentioned in the enclosed plan, I presume, are necessary for us because they are found so in the British hospitals." Experience during the remaining years of the war of the Revolution simplified the organization by removing many of the high-titled functionaries; and there seems no reason to doubt that had a little longer time been given, the establishment would have been resolved into a corps of medical officers taking rank each by seniority in his grade and assigned to duty in accordance with his rank.

For some years subsequent to the successful close of this war the army of the United States consisted of troops enlisted for short periods, with no provision for medical service other than that afforded by regimental medical officers.

In 1802 a new departure was taken in appointing army medical officers. The army at this time was so small that it was not possible for the few medical officers provided on a regimental basis to care for the sick of their commands, scattered as these commands were at various posts along the frontiers. Medical officers were therefore appointed to garrisons instead of to regiments. Additional troops levied in an emergency brought with them their regimental medical officers, and if the needs of the service required the establishment of general hospitals, surgeons of higher grade and rates of pay than the regular post surgeons were appointed for temporary service. In this manner the medical department was enlarged to meet the necessities of the army in the year 1812. During this war the only legislation materially affecting the department was a much-needed increase of pay for the regimental medical officers. Dr. James Tilton, who had been a hospital surgeon during the Revolution, was the chief of the department at this time with the title of "physician and surgeon-general." His management of affairs during the war appears to have given universal satisfaction. Many hospitals were established and broken up during the course of events, but all were well kept, fully provided with necessaries and competent for all the work thrown upon them. Some indeed, as that at Burlington, Vt., under the superintendence of Surgeon Lovell, Ninth Infantry, appear from the reports to have been model establishments. The regulations of these are extant, and it is readily seen that their high character was due to efficient administration, discipline, and cleanliness.

In 1818 a bill which organized the general staff of the army gave to the medical department for the first time in its history a permanent chief under the title of *surgeon-general*. To this position Surgeon Joseph Lovell was promoted on account of his excellent record. Hospital and garrison surgeons were consolidated under the title of *post surgeons*, and as these took rank after the surgeons of regiments, certain of the hospital surgeons who had served in high positions on important occasions had cause for dissatisfaction with the inferior status to which they were consigned by this arrangement.

The medical department was fortunate in having so able a man as Dr. Lovell appointed as its chief. He defined the duties of his subordinates, established an excellent system of accountability for property, improved the character of the medical reports, inspired his officers with the idea that as sanitary officers they had greater responsibilities than mere practising physicians and surgeons, and labored earnestly to have their pay increased and their official status raised in proportion to his views of the importance of their duties. He also established an equitable system of exchange of posts so that no officer would be retained unduly at an undesirable station.

In 1821 the finishing touches were given to the organization of the department by consolidating the regimental surgeons with the staff surgeons so that the corps consisted simply of one surgeon-general, eight surgeons with the rank and pay of regimental surgeons, and forty-five assistant surgeons with the pay of post surgeons, but as this number was insufficient to provide one medical officer to each of the military posts, the system of employing civilian physicians on contract was instituted.

Surgeon-General Lovell died in 1836 and was succeeded by the senior surgeon Thomas Lawson, then serving with troops in Florida.

Little of general interest occurred during the next ten years. The papers filed in the office of the surgeon-general during this period were arguments, opinions, and decisions on points connected with uniforms, rank, and precedence of medical officers and their right to enter into private practice in the vicinity of their stations. At last the concentration of troops on the Rio Grande and the probability of war with Mexico led to some changes. Two surgeons and twelve assistant surgeons were added to the medical staff, and ten new regiments were raised, each provided with one surgeon and two assistant surgeons. These were intended to be merely provisional appointments to be vacated at the close of the war. Ultimately, however, not only were the staff appointments made permanent, but ten additional assistant surgeons were authorized on account of the increasing needs of the department after the acquisition of California and New Mexico.

During the Mexican war the senior surgeons were assigned as medical directors and in charge of general hospitals; certain of the juniors were on duty at the hospitals and purveying depots, while the others served in the field as regimental officers with regular troops. Volunteer surgeons were on duty with their regiments, but some were occasionally detailed to hospital duties.

The additions to the numerical force of the medical department during and after the Mexican war proved insufficient for the needs of the many small garrisons into which our army became broken up; but although the surgeon-general repeatedly called attention to this, no increase was made until 1856, when four surgeons and eight assistants were added to the corps.

Surgeon-General Lawson died in 1861, shortly before the outbreak of the civil war. From the calls for large levies of troops and the feeling North and South that a desperate struggle was before the country it was evident that without large reinforcements the medical department would be unable to do its work successfully. At this time it consisted of one surgeon-general with the rank of colonel, thirty surgeons with the rank of major, and eighty-three assistant surgeons with the rank of first lieutenant and of captain after five years' service. In August, 1861, the addition of ten surgeons and twenty assistant surgeons was authorized. Some of this small staff corps took charge, as medical directors, of corps and armies, instructing the volunteer officers in the duties pertaining to camps and field hospitals; others acted as medical inspectors, aiding the directors in their work of supervision and education; some organized general hospitals for the sick that had to be cared for on every move of the armies, while others kept these hospitals and the armies in the field provided with medical and hospital supplies; the remainder were assigned to field service with the regular regiments and batteries.

Each volunteer regiment brought with it a surgeon and two assistants appointed by the governor of the State after examination by a State medical board. The senior regimental surgeon of each brigade became invested with authority as on the staff of the brigade commander, but as seniority in many instances was determined by a few days or weeks, it often happened that the best man for the position was not secured by this method. Congress therefore authorized a corps of brigade surgeons of volunteers, who were examined for the position by a board of regular medical officers. One hundred and ten of these brigade surgeons were commissioned.

In April, 1862, a bill was passed by Congress to meet the pressing needs of the medical department. This gave the regular army an addition of ten surgeons and ten assistant surgeons, and provided for a temporary increase in the rank of those medical officers who were holding positions of great responsibility. It gave the surgeon-general the rank, pay, and emoluments of a brigadier-general; it provided for an assistant surgeon-general and a medical inspector-general of hospitals, each with the rank of colonel, and for eight medical inspectors with the rank of lieutenant-colonel. These original vacancies were filled by the President by selection from the army medical officers and the brigade surgeons of the volunteers, having regard to qualifications only, instead of to seniority or previous rank. At the end of their service in these positions, officers of the regular force reverted to their former status in their own corps with such promotion as they were entitled to by the casualties of the service during their temporary occu-

pancy of these war positions. About the time of this enactment Surgeon-General Finley, Lawson's successor, was retired at his own request after forty years' service, and Assistant Surgeon William A. Hammond was appointed the first surgeon-general with the rank of brigadier-general. In December following eight more inspectors were authorized. Their duties were to supervise all that related to the sanitary condition of the army, whether in transports, quarters, or camps, as well as the hygiene, police, discipline, and efficiency of field and general hospitals; to see that all regulations for protecting the health of the troops and for the careful treatment of the sick and wounded were duly observed; to examine into the condition of supplies and the accuracy of medical, sanitary, statistical, military, and property records and accounts of the medical department; to investigate the causes of disease and the methods of prevention. They were required also to be familiar with the methods of the subsistence department in all that related to the hospitals and to see that the hospital fund was judiciously applied. Finally, they reported on the efficiency of medical officers and were authorized to discharge men from the service on account of disability.

Shortly after this the corps of brigade surgeons was reorganized to give its members a position on the general staff similar to that of the army medical officer and to render their services available to the surgeon-general at any point where they might be most needed, irrespective of regimental or brigade organizations. They henceforth became known as the *corps of surgeons and assistant surgeons of volunteers;* and the appointment of forty such surgeons and one hundred and twenty assistants was authorized.

In the military service promotion should be the reward for duty well performed, but during the War of the Rebellion little incentive of this kind was offered to medical officers. Surgeons with the rank of major had nothing to look forward to. They saw their comrades of the line, formerly their equals or inferiors in rank, mount upward step by step. They saw at the same time that a medical officer on duty as a medical director had only this same rank of major, although responsible for the work of five or six hundred officers, one-third of whom had the same rank, pay, and emoluments as himself. Not until toward the close of the war did Congress recognize the responsibilities of certain medical officers by giving the rank of lieutenant-colonel to medical directors of corps and of colonel to the director of an army.

During this great war the work of the medical department was performed by the regular medical officers and the corps of volunteer surgeons and assistant surgeons, both commissioned by the President, and by the large body of regimental medical officers commissioned by the governors of States. In addition to these, civilian physicians were employed under contract, mostly in the wards of the general hospitals established in the vicinity of Washington, D. C., and other cities. Just before the close of the war another class of medical officers was authorized. Regimental surgeons whose regiments had been mustered out on the expiration of their term of service were offered positions as acting staff surgeons as an inducement to continue in the service.

The latter part of the year 1865 was devoted to the breaking up of the depots and general hospitals, and next year the medical department was again placed on a peace footing with a personnel consisting of a surgeon-general; an assistant surgeon-general with the rank of colonel; a chief medical purveyor and four assistants, lieutenant-colonels; sixty surgeons, majors, and one hundred and fifty assistants, captains and lieutenants. In 1872 provision was made for a chief medical purveyor, with the rank of colonel; but in the mean time promotions and appointments were interdicted, so that at this time the reports of the surgeon-general speak in urgent terms of the crippled condition of his department. In 1873 there were fifty-nine vacancies, and to meet the requirements of the service one hundred and eighty-seven surgeons had to be employed on contract. At this time Congress authorized the appointment of assistant surgeons, but cut off two of the assistant medical purveyorships and ten of the sixty surgeons, prohibiting promotion until the number became thus reduced.

In 1876 the arguments in favor of increased rank for the medical corps were favorably considered by Congress, for in addition to the existing grades there were authorized four surgeons, colonels, and eight lieutenant-colonels, but the number of assistants was cut down to one hundred and twenty-five. No change has taken place since then except that of conferring on the lieutenant-colonels and colonels the respective titles of deputy and assistant surgeons-general, to correspond with similar titles in the other staff departments.

During the Spanish-American war the medical department of the army consisted of the regular establishment, with United States Volunteer surgeons appointed by the President, regimental surgeons and assistant surgeons appointed by the State governors, and surgeons under contract with the surgeon-general. At the present time (February, 1900) the regular establishment remains unchanged. The medical officers of the United States Volunteer regiments now serving in the Philippine Islands are appointed by the President, the State officers having all been mustered out with their regiments. The insufficiency of the present organization is such that over three hundred and fifty medical men are now serving under contract. It is hoped that the present Congress in legislating for the army will provide for the needful increase of the medical department. *Charles Smart.*

ARMY MEDICAL STATISTICS.—Broadly speaking, the main causes affecting the health of troops are the manner of living, the environment, and the food supplied. The first relates to the occurrence of overcrowding, imperfect ventilation, want of cleanliness, and inattention to personal hygiene. The second is typified in the accidents arising from atmospheric or telluric influences, such as rapid death from heat and cold, the comparatively transient influences of the seasons, and the slower and more durable effects of climate as modifying diseases of a restricted habitat. The last cause concerns the diseases brought about directly or indirectly by vicious alimentation. There are no diseases peculiar to the soldier; but military conditions are frequently such, particularly during a campaign, that the germs of disease are widely disseminated among an especially susceptible body of men—and hence a larger number are attacked and succumb than would probably have been the case in civil life. In character, the diseases developed in the military establishment call for no remark unless it be their unusually severe type, the regularity with which outbreaks of some affections recur, and the frequent tendency of others to become endemo-epidemic. The prevailing diseases in armies are, naturally, largely acute; and a large proportion of them are zymotic and hence theoretically preventable.

The purpose of army medical statistics is to define the influence of military life upon health and to permit the ready appreciation and accurate comparison of varying conditions of service and environment in their relation to the well-being of the soldier. Since each case of sickness in the military establishment at once becomes a matter of official record at the hands of competent observers, it follows that statistics so obtained are not only more comprehensive but more accurate than those bearing on the occurrence of disease among civilians. Unfortunately for their general utility, however, they are based upon a physically superior class, always existing under restricted and unusual conditions and frequently in unfavorable surroundings, and hence deductions which may be drawn from them cannot be legitimately applied outside the limits of the military service. Unfortunately, also, owing to the different systems of nomenclature and classification of diseases which have prevailed in the past, as well as to other causes which will be referred to later, it is not always possible accurately to compare the

sickness and mortality from special causes occurring in different armies, or even for the military establishment and civilian classes of the same nation. The committee on international military medical statistics which met at Budapest in 1894 has, however, formulated a plan which overcomes in great measure the difficulties with which army statisticians have had to contend, leads to a common basis of comparison, and will ultimately be the means of affording a large amount of information hitherto not available.

In the British army, statistics with regard to sickness and mortality were first compiled shortly after the close of the Peninsular war, but were published at long and irregular intervals. They gave much information with regard to the healthfulness of various stations, but the advent of the Crimean war caused their temporary discontinuance. In 1859 their publication was again resumed and they have since been issued annually. Army statistics have been collected in France and Germany since the Napoleonic wars, but have not been regularly made available for general use, frequently being issued only in part or not at all. Of late years, France has not given out full information as to the occurrence of disease and death among her military forces. In the United States army, satisfactory data for the period prior to 1840 are not available, and it is only since 1884 that figures sufficiently elaborate to be of any great value to the statistician have been compiled and published. At present the official returns show not only the amount of loss the army annually incurs from disease, but also the causes leading thereto; as influenced by race, age, length of service, arm of service, season, station, and other factors.

Little information is gained by recording the statistics of disease as a whole, since so many factors combine in the production of the final result that they must be separately studied to arrive at a proper understanding of the whole.

The main points upon which army medical statistics are based are as follows:

1. The number of admissions to sick report as compared with the number of persons furnishing the sick. This is accomplished by taking the actual numbers in both classes and reducing them to a comparable standard in rates per thousand. The numbers furnishing the sick are reduced by those sick in quarters or hospital; but as a general rule an equivalent number of men are returned to duty or are enlisted to replace the losses through death or disability. In our service statistics are based on the total strength.

2. The rate of deaths per thousand strength. This is obtained by the division of the total number of deaths occurring during the year by the mean annual strength, including the absent as well as those serving with the colors. The figures thus obtained are then reduced to rates per thousand.

3. The rate of discharges for disability from disease, per thousand strength—obtained by dividing the losses from discharge by the mean strength and then reducing to the above standard of comparison.

4. The total losses from disease; as determined by the sum of the rates for mortality and for discharge for disability from this cause.

5. The rate of constant sickness, or constant inefficiency. This is given by adding the numbers put down as remaining under treatment at the end of each day, week, or month and dividing by the number of days, weeks, or months in the period desired, again reducing to the comparable standard.

6. The number of days of service lost by each soldier. This is found by adding together the total number of sick days in a given period and dividing by the mean strength of the command for that period.

In all computations the figures are reduced to common terms of one year and one thousand strength.

Comparative Loss in Campaign from Sickness and Wounds.—Since the great military epidemics of antiquity—the destruction of the Assyrians under Sennacherib; the plague described as occurring during the Peloponnesian war; the pestilences which ravaged the Roman and Carthaginian armies; the great losses sustained by the army of Severus in the marshes of Caledonia—it has been established as a general rule that, in protracted wars, armies suffer much less from wounds than from disease. The constant advance in sanitation, however, based upon an accurate knowledge of etiological factors, has exerted a marked effect in diminishing military morbidity and mortality; and while in the future a comparatively high sick and death rate among troops engaged in war is always to be expected, it is scarcely possible that such disastrous epidemics as have prevailed in times gone by could be repeated in the future. Wars become shorter as they become, through modern refinements, more expensive; and troops, particularly in an aggressive and decisive campaign, are not now exposed to unhealthful influences to as great a degree as was the case when hostilities were more protracted. With improvement in the effectiveness of arms, both as regards range and rapidity of action, the proportion of casualty for any period of action must naturally be increased—and hence there is a constant tendency toward the approximation of the rates from wounds and disease.

From the records of the past, however, many valuable lessons can still be drawn. In 1809, during the Walcheren expedition, the mortality in the British army from disease was 346.9 per thousand effectives, while only 16.7 per thousand were killed by the enemy. A few years later the British army in Spain lost three times as many men by disease as by the result of conflict, and the sick rate mounted to such proportions that more than twice the number of men composing the army passed through the hospitals during a single year. In the Russian campaign against Turkey, in 1828, it was estimated that 80,000 men died of disease and 20,000 in consequence of wounds. During General Scott's campaign in Mexico the losses from disease alone exceeded 33 per cent. of the effective strength of the forces under his command, and in a single regiment of Indiana volunteers which entered the service 1,000 strong only 400 returned to the State for muster out. Laveran states that in the Crimean war the allies lost 52,000 men in six months, of which number 50,000 men were unharmed by the Russians; while during the entire war, according to Viry, the French lost, in round numbers, out of a total force of 300,900 men, no less than 95,000, of whom 75,000 died of disease and only 20,000 died on the field or succumbed to wounds. In this campaign nearly one-fourth of the French medical officers are said to have succumbed to sickness. During the war in Italy, in 1859, a period of hostilities of only short duration, there were, from the French force of 200,000 men, 129,950 admissions to hospital. In the war carried on by France in Mexico the mortality from gunshot and that from sickness was as 10 to 29.

The mortality among the United States forces in the civil war was divided as follows:

Mortality.	White.	Colored.	Total.
Killed in battle	42,724	1,514	44,238
Died of wounds	47,914	1,817	49,731
Died of disease	157,004	29,212	186,216
Died, cause unknown	23,347	837	24,184
Total	270,989	33,380	304,369

From the most reliable data available the deaths in the armies of the Confederate States during this struggle did not fall short of 200,000, three-fourths of which number were due to disease and one-fourth to the casualties of battle.

In 1866, in the war against Austria, out of a total strength of 437,260, the Prussians lost in an unusually brief and decisive campaign 6,427 men by sickness and 4,450 at the hands of the enemy. The Franco-German war, in 1870–71, furnishes the only exception to the general rule that more men are killed by disease than by the weapons of the enemy, since of the German army 33.7 per thousand strength fell in battle while only 18.6

per thousand died of disease. This admirable result was largely due to the proper observance of sanitary precautions; assisted, no doubt, by the brevity of the campaign, the rapidity of the movements, and the fact that active operations were conducted during the most healthful season of the year. In the Russo-Turkish war of 1878, according to Viry, the Russians lost 102,799 men, of whom only 16,578 were killed by the enemy. During the Spanish American war of 1898, for the five months which included the total period of hostilities, of the 274,717 officers and men enrolled in the United States forces there were only 345 men killed by the enemy while 2,565 succumbed to disease. For the whole year of 1898 the deaths from wounds in our service gave a rate of 0.62 per thousand strength, the killed in battle amounted to 2.79 per thousand strength, while the deaths from all causes aggregated 30.31 per thousand. Even in July, the month in which aggressive operations against Santiago were conducted, the killed in action amounted to only 1.25 per thousand while the deaths from disease were 1.78 per thousand.

An interesting side light on the later results of hard campaigning is given by Rosse, in his statement that of the old soldiers carried on the United States pension rolls those disabled by disease are more than four times greater in number than those pensioned for wounds.

Death Rates in Civil and Military Life.—The difficulties attending an accurate comparison of death rates for the military service and those of civil life are necessarily very great. Owing to the rejection of intending recruits many individuals are at once returned to private life whose early demise would otherwise have gone to swell the military death rates. Further, the army is maintained as a select body of physically sound men, and its weaklings are constantly undergoing elimination from the service ultimately to increase the mortality of civil life. Hence the civilian rates are unduly increased, while army statistics fail to show all the deaths presumably due to military service—and it is obvious that the more rigorously the standard for the soldier is maintained as regards physical excellence, the more favorable the showing apparently made for a military life. Vallin, in France, in 1871, placed the probable error due to the above causes at as much as 9.19 per thousand, thus practically doubling the figures for the military death rate of his time. Viry considered this allowance to be too high, but believed that a rate of 3.60 per thousand, for such as leave the colors with incurable disease should be added to the military and subtracted from the civilian death rates; thus making a difference of 7.20 per thousand. The estimates of Marvaud placed the probable error at 4 per thousand. While it is probably correct for the French service to add 3.60 or even 4 per thousand to the military death rate, to deduct the same number from the civilian rate involves the broad assumption that the numbers in each class exactly correspond. For our own service the immense disproportion existing between the present small army of 65,000 men and the large number of males of the military age living in the United States renders the influence of the comparatively small number of soldiers who may be discharged for incurable disease upon the civilian death rate of so little importance that it may practically be disregarded. The census returns for 1880 give the annual death rate for disease as 6.97 per thousand for all males between the ages of twenty and forty-five years. During the same year the mortality from disease in the United States army was 5.88 per thousand—apparently a distinct advantage in favor of the military service. If, however, Viry's factor, above mentioned, be accepted as correct for our service, the true military mortality becomes 9.48, or 2.51 per thousand in excess of the civilian rate for the same period. As it is probable that since that time the death rate in the military service has diminished in proportionately greater degree than has been the case in civil life, it may be fairly assumed that, under conditions of peace, the death rate in our army is at present but slightly in excess of the mortality for the same class in civil life. The results obtained by Farr in his comparison of the death rate in the British army with the corresponding classes of civil life, made a generation ago, are as follows:

Age.		Death rate per 1,000.
20-25.	Soldiers	17.0
	Civilians	8.4
25-30.	Soldiers	18.3
	Civilians	9.2
30-35.	Soldiers	18.4
	Civilians	10.2
35-40.	Soldiers	19.2
	Civilians	11.6

According to Notter and Firth, the present death rate of the civil male population in England, at the soldier's age, is as follows:

Age.	Mortality per 1,000.
20-25	5.4
25-35	7.4
35-45	12.8

Between the ages of 20 and 34 the mortality is in favor of the soldier, but after 35 the mortality is reversed and the civil rates are lower.

For the British service the death rate for the home stations was 3.42 per thousand in 1897 and 4.68 per thousand for the decade 1887-1896. If the civilian death rate for all males of the military age be accepted as about 7 per thousand, the showing made compares favorably with similar figures for the German army and is superior to the French mortality rates. This is certainly a great improvement over the conditions existing in 1856, when it was shown that the mortality in the army at large was twice as great as among the civilian population, and in the case of the Foot Guards three times as great.

As regards the German army, it was recently stated by its surgeon-general that during the early part of this century the death rate of the male civil population of Prussia, between 20 and 30 years of age, was lower than that of the military death rate, the figures being 14 per thousand for the army and 10 per thousand for the civil population. This condition is now reversed, and in 1893 the death rate in Prussia for the civil male population from 20 to 30 years of age was 6.38 per thousand, while at the same time the mortality for the German army was 3.00 per thousand. While these results are certainly admirable and are undoubtedly in large part due to careful observance of sanitary regulations, it should be remembered that soldiers unable to maintain the required physical standard are probably more thoroughly eliminated in the German army, and at an earlier period in their military training, than in other services.

In the French army, on the home stations, the average annual death rate from 1882 to 1890, inclusive, was 7.88 per thousand strength; while Bertillon fixed the annual mortality among the civilian male population, between the ages of 20 and 25, at 10.60 per thousand. Marvaud, however, believed that the estimate made by Bertillon was too low, and placed the annual death rate for civilians of the military age at 12 per thousand. Using Marvaud's coefficient of error, given above, the corrected rate for the French military service would become 11.88, while it would be 8 per thousand for the same class in civil life. Marvaud concludes "that, in spite of all ameliorations which have been introduced, chiefly of late years, into the hygienical surroundings of the French soldier, his mortality rate is still elevated and certainly exceeds that of the same sex and age in civil life."

Loss of Time from Sickness.—In the United States service the annual average number of days lost per man, for the decade 1886-1895, was 14.64. For the year 1896 it was 12.43, and in 1897 it was 13.08. In comparing the number of days lost by white soldiers with those lost by colored troops, the showing is slightly in favor of the latter. For the entire British army during the decade 1887-1896, the number of days lost per man was 21.38, while during 1897 it was 22.72. Among the British troops at the home stations the number of sick days per

man did not differ very greatly from those of our own army for the same periods, being only a fraction of one day in excess. According to Rosse, in a statement of the morbidity of various armies issued about 1884, the lowest rates given were those of the Portuguese, Austro-Hungarian, Italian, and German armies, the sick days of each man in the effective force being from 13 to 15 yearly among the troops of these nations, while in the French and English armies, prior to that date, the rate had been 16 to 17 annually.

As compared with the time lost by the corresponding classes in civil life, Rosse noted that for the period 1862 to 1892 the average annual number of days of sickness was 6 to 8 for each workingman belonging to various mutual aid societies; he fixing the general military morbidity for the same period at figures two and one-half times greater than those of the corresponding civil classes. According to Paget the following rate of sickness may be expected for different ages for males of the English working classes, such as incapacitates for work: at 20 years expect 4 days of sickness yearly; at 20–30 years expect 5 to 6 days of sickness yearly; at 45 years expect 7 days of sickness yearly.

Marvaud states that, in 1894, the French soldier lost 13 days annually—9 in hospital and 4 in barracks—while his civilian compatriots of corresponding age lost on an average only about half that time; notwithstanding the fact that the hygienic surroundings in the military service were much superior to those of civil life. While in time of war or active operations the existence of a high rate of inefficiency and the loss of a greater amount of time are to be anticipated, such conditions, as compared with those of the corresponding classes of the male civil population, should not, theoretically, obtain in time of peace. Their actual existence under the latter condition is probably due to the fact that the workingman does not feel able to stop his daily task except for serious illness, while the soldier—whose pay and living are assured and whose medical attendance is gratuitous—is inclined to abuse his privileges, often endeavoring to get his name on sick report for the slightest indisposition, or none at all, and to have it retained there for as long a period as possible; this being particularly attempted when any unusually irksome or disagreeable task is to be performed. That such, indeed, is the case is demonstrated by the fact that, according to Billings, it may be estimated that for every case of death there is an average of two years sickness in the civil community; while in the United States army, for the absolute number of deaths occurring and days of service lost during the year 1897, the proportion was such as to show a total of 3,867 days of sickness to each death reported. This gives a total of 10.6 years sickness for each death; a rate more than five times greater than that obtaining in civil life and one which can be explained only by the above hypothesis. In view of the unfavorable showing, in this respect, made by military statistics it would appear that greater discretion and severity should be exercised in admitting the soldier to sick report; and that, if once admitted, his earlier return to his duties would usually be productive neither of injury nor hardship.

Race as Influencing Military Mortality and Morbidity.—While satisfactory data on this subject as regards foreign armies are naturally not available, the several rates from disease in our own service, with its heterogeneous personnel, have been calculated according to nativity. For the seven years 1890–1896, they were determined, per thousand strength, to be as follows:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
United States	1,043.43	30.74	12.98	3.96	16.94
Ireland	962.05	26.87	14.52	5.46	19.98
Germany	810.10	24.67	13.20	4.14	17.34
England	907.11	23.56	12.46	4.26	16.72
Canada	1,033.14	32.81	18.87	4.16	23.03
Scandinavia	886.08	26.55	13.33	5.17	18.50
Scotland	852.38	25.64	12.50	1.47	13.97
Switzerland	893.75	27.82	12.31	2.90	15.11
Austria	807.14	21.63	16.53	2.67	19.20
Denmark	836.93	26.21	13.33	5.55	18.88
France	1,049.43	30.89	10.56	7.04	17.60
All others	821.42	23.90	13.66	3.86	17.52

It should be noted, however, that the figures given for the countries named in the latter half of the above table are not to be considered as absolute, since they are not based upon a sufficiently large number of men to avoid the possibility of error. These rates are, however, of particular interest, since, so far as they go, they tend to bear out the popular belief that the native-born American possesses a greater proportion of vital force and greater power of resistance against death than does the foreigner.

Race proclivity, as regards sickness, is well shown by the records of the British forces in the West Indies, in which, for the ten years 1876–1885, the admissions per thousand of strength for the whites were 893.5, colored 1,074.1; discharges, white 13.95, colored 26.79; constantly non-effective, whites 44.68, colored 58.38; deaths, whites 15.42, colored 15.38. (See also chart on p. 499.)

In the United States service, for the decade 1877–86, the death rate among the whites per thousand was 9.97 and for the colored 12.91. There has been, however, a constant tendency for the past twenty years toward the approximation of the rates for the whites and blacks in our service; and the relative rates per thousand for the white troops of all nationalities as compared with those for the colored troops, during the year 1897, were as follows:

	Admissions to hospital.	Constantly non-effective.	Discharged for disability.	Deaths.	Total losses.
Whites	35.72	11.04	9.62	5.05	14.67
Colored	37.24	10.89	9.51	5.89	15.40

In the distribution of diseases according to nativity, typhoid fever and rheumatic fever had their greatest prevalence in our service, for the years 1890–1896, among the Canadians and Scandinavians. The highest admission rates for consumption were 5.70 among the French and 4.76 among the Scotch; the lowest rates were 1.42 among the English and 1.49 among the Germans, the rate among the natives of the United States being 3.33. Pneumonia was more frequent among Canadians, 5.18, and Scotch, 4.76, than in men of other nativities. The rate for this disease for the natives of the United States was 3.90. Venereal disease prevailed more among men born in the United States and Canada than among the others, the admission rates for these two classes being 93.98 and 91.92 respectively; the Irish and Swiss had the lowest rates, 47.66 and 50.96. The Irish, however, had by far the largest relative number of cases of alcoholism, 90.96. The smallest rates for this cause were given by the Danes, 12.59, and Austrians, 19.00; the admission rate for the native-born American soldier having been 28.51 for this cause.

Sickness and Death Rate as Affected by Season.—Military morbidity and mortality are to a certain extent influenced by seasonal changes; varying according to the climatic conditions prevailing in each country or locality, by which the propagation of certain affections is either favored or retarded. In the French army the admissions to hospital for disease, in time of peace, reach the maximum of 57 or 58 in January and fall to the minimum of about 38 per thousand in September. In the Italian army, for the period 1872–1892, the greatest amount of sickness occurred in March and the least in November. In the United States service the mid-summer period is

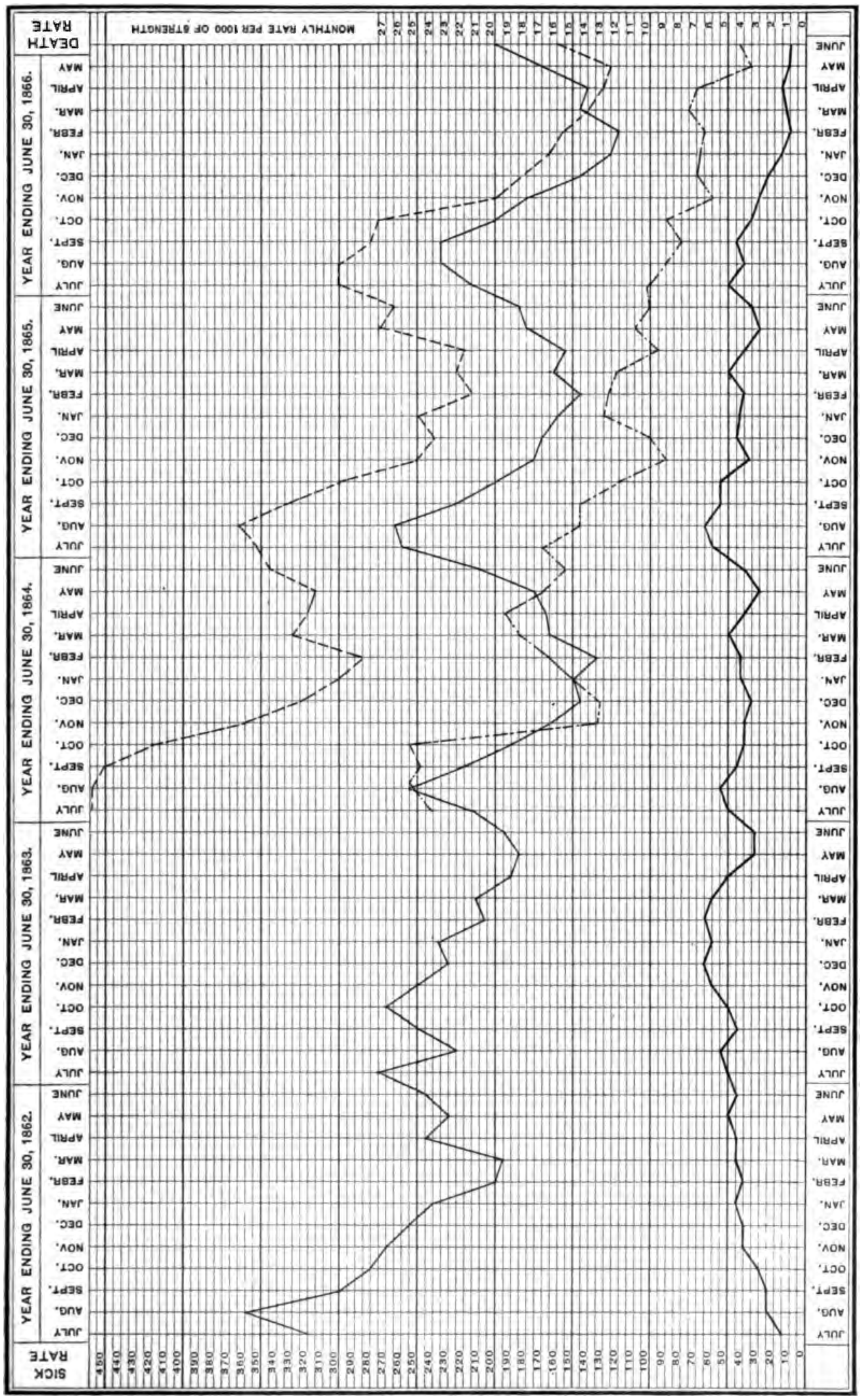


Diagram Showing the Sickness and Deaths among the White and Colored Troops of the United States Armies during the Civil War and the Year Following That War, Expressed in Rates per Thousand Strength.

Mortality, White Troops ———— *Sickness, White Troops* ————
Mortality, Colored Troops —·—·—·— *Sickness, Colored Troops* — — — —

(From the "Medical and Surgical History of the War of the Rebellion.")

the most unhealthful, while the late fall and early winter gives the least sickness. The monthly prevalence of disease in our army, in time of peace, as given in the figures for the year 1892, is shown in the following table.

	Total admissions to hospital, per thousand of mean strength, for disease and injury.	Constantly non-effective, per thousand of mean strength, from disease and injury.
January	148.65	49.54
February	107.87	41.69
March	108.03	39.27
April	92.53	37.34
May	98.66	37.67
June	101.94	38.34
July	108.26	37.46
August	106.37	36.86
September	108.57	38.42
October	97.48	38.79
November	91.97	39.38
December	98.34	40.44

For the year 1898, when the army, if not entirely engaged in active military operations, was, after the month of March, still in the field and on a war footing, the monthly rates per thousand strength were as follows:

	Admissions from disease.	Discharges from disease.	Deaths from disease.	Total losses from disease.
January	68.11	0.40	0.33	0.73
February	59.68	.40	.18	.58
March	65.75	.50	.21	.71
April	65.12	.95	.24	1.19
May	80.90	.31	.21	.52
June	68.25	.29	.36	.65
July	150.15	.31	1.81	2.12
August	254.61	.41	6.14	6.55
September	271.79	.35	4.73	5.08
October	200.48	.79	2.06	2.85
November	186.06	1.11	1.07	2.18
December	212.63	1.14	.84	1.98

Branch of Service as Affecting Health.—It has long been noted that troops of certain arms are more prone to disease and death than are others; this being explainable by the character of the duties each is required to perform, as well as by the diverse conditions of environment under which they are, through military necessity, forced to exist. As compared with infantry and artillery, the cavalry service may be considered to be somewhat more unhealthful and dangerous to life; this being due to the more arduous nature of the service, to the greater opportunity for accident, and to the uncleanly nature of a large part of the duties of the mounted soldier. In time of peace, for all armies, the mortality and sickness in the infantry is usually less than in any other of the main branches of the service, but in war this favorable showing does not continue.

In the United States army, for the seven years 1890–1896, the rates for disease alone, per thousand enlisted men, according to branch of service, were:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
Infantry	916.27	27.96	13.67	4.34	18.01
Cavalry	1,076.56	30.87	13.36	3.98	17.34
Artillery	1,163.61	31.81	15.61	2.94	18.55
Ordnance	1,007.15	25.69	9.79	7.20	16.99
Engineers	1,371.55	29.88	7.56	2.84	10.40
Medical department	468.85	14.99	11.24	5.14	16.38
All others	941.51	30.23	10.15	5.07	15.22

The high death rate noted in the enlisted strength of the Ordnance Department is probably largely dependent on the greater age of these men; many being old soldiers, superannuated, unfit to stand hard service and broken in constitution by the hardships of a former active life.

For the period above noted the rates for all causes were:

	Admissions to hospital.	Constantly non-effective.	Discharges for disability.	Deaths.	Total losses.
Infantry	1,154.21	35.36	16.72	6.49	23.21
Cavalry	1,464.10	43.92	17.61	7.25	24.86
Artillery	1,457.87	41.11	18.47	5.30	23.77
Ordnance	1,187.38	31.81	11.23	10.65	21.88
Engineers	1,684.92	38.45	7.88	4.73	12.61
Medical department	527.04	17.08	12.19	6.09	18.28
All others	1,100.02	34.77	12.12	6.13	18.25

The high rate of admissions among the engineer troops was due to injuries and malarial fevers, with a considerable excess of alcoholism, bronchitis, diarrhœa, and rheumatism. The disabling causes which produced the high rate in the cavalry as compared with infantry were injuries, which gave a rate of 387.54 as compared with the infantry rate, 237.94; but the excess of admissions among the cavalry was not thus entirely accounted for, since disease also gave a slightly higher death rate. Malarial affections were the principal causes of this excess, but diarrhœa, boils and abscesses, and conjunctivitis also aided in making up the total.

Among the officers, for the above period, the sick rate was largest in the artillery, 980.11 per thousand. Non-efficiency was greatest among officers of the cavalry and artillery—53.90 and 52.57 respectively. Medical officers had a higher rate (47.07) than infantry officers (46.05). The death rate per thousand among officers, according to branch of service, was as follows:

Infantry	8.81
Cavalry	10.34
Artillery	6.08
Ordnance	17.41
Engineers	11.07
Medical department	10.20
All others	12.32

Death from injury was relatively more frequent among ordnance officers than in those of other corps.

Marvaud gives the following figures as showing the comparative mortality in different branches of the French service for the six years 1880–1885, inclusive.

	Death rate.	Loss by invaliding.	Total losses.
Engineers	5.2	14.4	19.6
Light infantry	7.0	11.7	18.7
Artillery	7.4	12.9	20.3
Cavalry	8.8	13.2	22.0
Infantry of the line	10.2	16.6	26.8
African light infantry	17.2	14.5	31.7
Foreign legion	19.8	8.7	28.5

In the English service, in 1897, the following rates per thousand obtained for troops on the home stations.

	Deaths.	Constantly non-effective.
Infantry	2.78	44.79
Royal engineers	3.64	17.75
Cavalry	3.98	42.39
Royal artillery	4.00	32.49
Foot guards	4.20	63.03

The Influence of Length of Service upon Morbidity and Mortality.—The most extensive figures for the United States army upon this subject, compiled to include a period of seven years, merely divide the men into those who have had less and those who have had more than one year of service—and these show that recruits during their first year with the colors are especially liable to sickness. For the entire period (1890–1896), the admission rate to hospital of this first class was 2,122.17, while the

The younger men, both officers and soldiers, appear particularly susceptible to disease as well as prone to injury. For the period noted above typhoid fever was observed to be much more prevalent among those under 30 years of age. The rate for this disease in men from 20 to 24 years of age was 10.31; from 25 to 29 years, 5.74; from 30 to 34 years, 2.58. Enlisted men under 25 years of age suffered more from malarial fevers than did officers of the same age; but with the advance of years the rates of the men came to differ but little from those of their superiors. The higher rates for venereal disease were given by men under 30 and particularly by those under 25 years of age; but, on the other hand, the rates for alcoholism increased with age. Tuberculosis appeared to be equally distributed among men between the ages of 20 and 50 years, but the excess of diarrhœal troubles was confined to soldiers under 25 years. Rheumatic fever was not specially prevalent among young men, susceptibility being increased after the age of 40 or 50 years. The rates for pneumonia were considerably larger after 45 years of age—as were also those for kidney disease.

In the French army, for the decade 1875–1884, per 1,000 strength, the average annual death rate for all causes, as given by Marvaud, was:

Under 20 years of age	6.72
From 20 to 22 years of age	10.92
From 22 to 23 years of age	9.38
From 23 to 26 years of age	8.59
From 26 to 30 years of age	7.14
From 30 to 35 years of age	8.51

The class less than 20 years old is not only a very small one, amounting, according to Bertillon, to only about three per cent. of the whole, but the young men composing it are all volunteers and before enrolment are subjected to an exceptionally severe physical examination, so that only the best lives are accepted. Hence for the French army at large the first year of service may be considered to begin at the age of 20–22 years. In commenting on the excessive mortality of the younger soldiers, Marvaud says: "It is during the first year of service that the number of deaths attains its maximum, a fact which proves the dangers provoked by acclimation to a military life." The influence of age upon sickness, in time of war, is even more marked than during peace. According to Gayet, in the campaign of Benin the total losses by deaths and disease from repatriation were as follows:

	Per Cent.
Foreign legion	9.7
Artillery of the marine	23.3
Engineers	24.2
Infantry of the marine	39.0
African battalion	47.9

In the two last classes the men were young and illy developed, ranging from 19 to 22 years of age; in the foreign legion the men were older, being between the ages of 25 and 35 years.

Influence of Military Rank as Affecting Health.—The report of the surgeon-general for 1897 gives statistics for our army to include the seven years 1890–1896, this being equivalent to a total strength for one year of 14,859 officers and 174,988 enlisted men. These figures show a sick rate of 765.69 per thousand for the officers and 1,258.90 for the men; but the inefficiency rate of the former class was much greater than that of the latter, being 44.27 per thousand as compared with 37.63 per thousand in the case of the enlisted force. The average death rate for officers was 9.56 per thousand, while among the enlisted men the annual mortality was only 6.52 per thousand. Such an unfavorable showing made by the officers as regards the rates for death and inefficiency is largely to be explained by the fact that the military life of the enlisted soldier practically ceases at the age of 44 years, only 6.50 per cent. of this class remaining in service after that age; while of the officers included in the tabulation referred to, 37.25 per cent. were over 44 years of age. The latter class, then, while sharing largely with the enlisted men in the hygienic disadvantages of immaturity, had, in addition, the diseases of beginning old age and the results of long years of hard service to increase its death rate. It is to be noted that during this same period young officers under 25 years had only 784.20 admissions per thousand for disease, where the soldiers of the same age had an admission rate of 1,359.63; while the non-efficiency rate of the former was 29.61, as compared with the rate of 39.52 for the latter. This would indicate that if the same attention was given to sanitary details by the young soldier as by the young officer, his rate of constant sickness would be correspondingly reduced.

The influence of petty rank and length of service on sickness in the French army is shown in the subjoined table, constructed from data given by Marvaud covering the year 1888:

	Admissions per 1,000 strength.	
	Detention rooms.	Hospitals.
Non-commissioned officers	111	248
Men having more than one year of service	260	172
Men having less than one year of service	567	299

The proportionately large number of non-commissioned officers treated in hospital is explained by Marvaud as being due to lack of suitable accommodations in the detention rooms for this class.

Health of Troops in Peace.—The individual significance of the several factors which, taken together, determine the sanitary condition of our army in time of peace will be readily appreciated by reference to the subjoined table. Diarrhœal affections have the highest admission rate for sickness, but the mortality from this cause is not great. Malarial diseases rank second in frequency, but, as shown by statistics, they are not of severe type and are readily amenable to treatment. Venereal diseases occupy third place in importance as regards admissions, but the constant non-efficiency through their influence is much greater than that from any other cause. Rheumatism and myalgia together furnish a large proportion of admissions and discharges, as does also bronchitis. The admissions for alcoholism are slightly above the general mean, but the rates for death and non-efficiency from this cause are small. All the rates for typhoid fever are low. As to injuries, the several figures for contusions and sprains are all large—those for wounds, excluding gunshot injuries, being considerably lower than those for contusions, but still somewhat in excess of the general average. (See Table A, p. 503.)

With regard to sickness, deaths, and non-efficiency in the British service for the home stations, the fact which at once attracts attention is the high ratio given by venereal affections; the admissions from this cause being more than half again as high as from any other affection or group of diseases. For gonorrhœa, primary and tertiary syphilis, the individual rates for non-efficiency are much higher than for such diseases as are summarized as affections of the respiratory and digestive systems. The rates for rheumatism and influenza are high, while diseases of the skin and of the connective tissue are common. Alcoholism is a minor factor in increasing the rates for sickness, deaths, and non-efficiency. (See Table B, p. 504.)

Decrease in Rates under Conditions of Peace.—That improvement in the sanitary administration and state of armies is constantly being made will be unhesitatingly admitted, but few are aware of the stupendous progress in this respect which, particularly during the past generation, has been accomplished by military hygiene. Not only is this the case in our own service, but in foreign armies also, and, on reviewing the sanitary conditions which for their time were considered to be excellent, it is apparent that still further decrease in the several rates may justly be anticipated for the future.

For the U. S. army the accompanying charts (see pp. 505 and 506) so well illustrate the remarkable decrease in sickness and death which has occurred during the past three-score years that any extended discussion of the matter would seem to be superfluous. Suffice it to say that the death rate for the five years preceding the Spanish-American war was about three and one-half times less than that for the five years preceding the war with Mexico, while the rate for sickness underwent a diminution of about two and one-third times during the period included by these dates. Since 1872 the death rate from all causes has dwindled to about forty per cent. of what it was at that time, while the death rate from sickness alone has fallen almost as much; and during the same period the rate for admissions to sick report has diminished more than one-half.

In the German army, according to official figures recently submitted to the Reichstag, the number of admissions to hospital from disease, per thousand strength, underwent a decrease from 1,496 in the year 1868 to 867 in 1894. In 1868 the annual death rate per thousand was 6.9, 4.82 in 1879, 3.24 in 1888, and only 2.60 in 1896—a magnificent result, in the attainment of which the due observance of sanitary detail, and especially the careful selection of recruits, were main factors. Military epidemics, in this showing of the German army, have above all lost ground. Smallpox is rare, and caused only two deaths during the twenty years 1873–1893. Dysentery was reduced from 6.8 per thousand strength in 1874 to 0.39 in 1894. Typhoid fever gave a rate of sickness of 33.8 per thousand strength in 1868 and 2.4 per thousand in 1894. The typhoid death rate was 2.2 per thousand in 1868 and 0.81 per thousand in 1894. Malaria showed a rate of sickness of 27.6 in 1868 and

A.—Ratios of Admission to Sick Report, Discharge, Death, and Constantly Non-Effective of the United States Army for the Decade 1886–95.

For the Decade 1886–95.	White.				Colored.				Indian.				Total.			
Mean strength	A. G., 24,301.		S. G., 22,071		A. G., 2,379.		S. G., 2,188		A. G., 227.		S. G., 213		A. G., 26,907.		S. G., 24,472	
Causes of admission to sick report.	Admissions.	Discharges.	Deaths.	Constantly non-effective (a).	Admissions.	Discharges.	Deaths.	Constantly non-effective (a).	Admissions (b).	Discharges (b).	Deaths (b).	Constantly non-effective (b).	Admissions.	Discharges.	Deaths.	Constantly non-effective (a).
Special.																
Vaccinia	33.76	0.004	.....	1.06	26.24	.....	.....	0.76	106.25	.....	.....	4.14	33.72	0.004	.....	1.06
Typhoid fever	5.94	.01	0.64	.91	2.10	.....	0.50	.29	.47	.....	.....	.02	5.55	.01	0.62	.84
Malarial infections	96.20	.09	.14	2.48	64.50	0.04	.38	1.74	32.91	.....	.....	.47	92.82	.08	.16	2.40
Rheumatic fever	5.11	.07	.02	.59	5.76	.04	....	.53	4.23	0.44	.....	.58	5.16	.07	.02	.58
Tuberculosis of the lungs	2.93	1.52	.44	.70	3.93	1.85	.84	.97	25.39	11.44	7.04	3.55	3.21	1.63	.54	.75
Syphilis	17.45	1.98	.02	1.68	20.98	3.36	.04	2.02	15.51	2.64	.....	1.76	17.75	2.11	.02	1.71
Gonorrhœa	38.97	.26	.....	2.30	32.41	.04	....	1.52	63.00	.....	.....	3.17	38.60	.24	.....	2.24
All venereal diseases	75.89	2.30	.02	5.26	78.48	3.40	.04	5.21	98.26	2.64	.....	5.77	76.32	2.40	.02	5.26
Alcoholism and direct results	42.37	.07	.22	.47	4.89	.04	....	.05	4.70	.....	....	.07	38.69	.07	.20	.43
Neuralgia	24.69	.16	.....	.62	36.94	.04	....	.57	15.05	.....	.....	.17	25.70	.14	.....	.62
Tonsillitis	41.35	.004	.01	.66	54.49	.....	....	.73	29.62	.....	.....	.41	42.42	.004	.01	.66
Colic and constipation	32.10	.02	.....	.29	49.18	.04	....	.41	31.50	.....	.....	.34	33.62	.02	.....	.30
Diarrhœal diseases	115.68	.22	.13	1.34	99.75	.17	.13	1.14	45.61	.....	.....	.55	113.65	.21	.13	1.32
Diseases of the heart	5.79	1.36	.42	.53	4.94	1.18	.25	.30	2.35	.88	.44	.16	5.69	1.34	.41	.51
Coryza	33.56	.....	.....	.29	41.36	.....	....	.30	12.69	.....	.....	.11	34.08	.....	.....	.29
Bronchitis	67.94	.23	.02	1.37	69.26	.17	....	1.20	56.89	.....	.....	.82	67.97	.22	.02	1.35
Pneumonia	3.88	.06	.66	.41	6.90	.08	1.51	.60	10.34	.....	.88	.70	4.20	.06	.74	.43
Diseases of the kidneys	1.72	.20	.23	.21	2.83	.29	.34	.22	.....	.....	.....	.....	1.80	.20	24	.21
Rheumatism and myalgia	73.28	1.59	.02	3.65	116.33	2.02	....	4.56	50.78	1.32	.....	1.54	76.94	1.63	.02	3.71
Boils and abscesses	43.74	.02	.004	.99	26.51	.04	....	.67	42.31	.....	.....	1.21	42.18	.02	.004	.97
Conjunctivitis	11.86	.06	....	.32	14.49	.21	....	.45	44.67	.....	.....	1.21	12.38	.07	.....	.34
All diseases of the eye	17.95	.98	.....	.78	26.74	1.13	....	1.04	62.06	.44	.....	1.98	19.13	.99	.....	.82
All diseases of the ear	7.67	.54	.004	.34	3.70	.13	....	.16	8.46	.....	.44	.16	7.32	.50	.01	.33
Contusions and sprains	130.04	.23	.01	3.33	145.86	.21	.04	3.36	128.82	.....	....	3.02	131.46	.23	.01	3.33
Dislocations	2.57	.11	.004	.20	1.87	.13	....	.11	6.11	.....	.....	.52	2.54	.11	.004	.20
Fractures, not gunshot	6.99	.52	.10	1.20	5.12	.34	.08	.88	11.75	.....	1.76	1 52	6.86	.50	.11	1.17
Wounds, not gunshot	50.21	.20	.05	1.48	68.07	.21	.08	1.99	91.20	.....	.....	2.10	52.16	.20	.05	1.53
Wounds, gunshot	3.30	.64	.96	.57	7.27	.80	1.60	.97	7.05	.88	4.84	1.05	3.69	.66	1.05	.61
Grouped.																
Infectious diseases, general and local	302.66	4.15	1.73	13.18	276.73	5.76	2.40	11.55	350.26	15.41	7.04	17.45	300.76	4.39	1.84	13.09
Diseases of nutrition, general	2.55	.59	.09	.23	2.10	.38	.04	.18	1.41	.....	.44	.03	2.50	.56	.09	.22
Diseases of the nervous system	96.67	3.12	.79	2.32	77.07	2.14	.46	1.57	41.38	1.32	.44	.68	94.44	3.02	.76	2.24
Diseases of the digestive system	278.10	.75	.65	4.40	300.59	.76	.38	4.08	180.54	.....	.....	2.57	279.26	.75	.62	4.35
Diseases of the circulatory system	7.14	1.71	.51	.69	5.30	1.26	.50	.36	2 35	.88	.44	.16	6.93	1.06	.51	.66
Diseases of the respiratory organs	113.00	.58	.78	2.49	130.55	.34	1.81	2.57	92.15	1.32	.88	2.46	114.39	.56	.87	2.50
Diseases of the genito-urinary system	11.33	.81	.24	.85	14.49	.97	.34	.93	7.99	.44	.....	.21	11.58	.82	.25	.85
Diseases of the lymphatic system and ductless glands	5.35	.07	.004	.44	6.95	.....	....	.47	11.28	.....	.....	.93	5.54	.06	.004	.45
Diseases of the muscles, bones, and joints	79.16	2.67	.01	3.74	121.41	3.24	.04	4.89	53.60	1.76	.....	1.38	82.70	2.71	.01	3.83
Diseases of the integument and subcutaneous connective tissue	79.47	.23	.02	2.11	50.47	.25	.08	1.58	71.93	.....	.....	2.19	76.81	.23	.02	2.06
Diseases of the organs of special sense	27.53	1.65	.01	1.27	31.45	1.39	....	1.26	72.40	.44	.44	2.19	28.27	1.62	.01	1.28
Unclassified	2.79	....	.004	.07	5.21	.....	....	.08	2.82	.....	.....	.01	3.00	.....	.004	.07
General injuries	3.25	.02	1.02	.08	1.87	.04	.42	.04	.....	.....	.44	.....	3.10	.03	.06	.07
Injuries to special parts	245.13	3.36	1.26	8.47	289.26	3.45	1.98	9.35	302.30	2.64	6.60	9.76	249.57	3.36	1.37	8.57
Total for diseases	1,005.77	16.34	4.84	31.80	1,022.31	16.48	6.05	29.53	888.11	21.57	9.68	30.27	1,006.22	16.39	4.09	31.02
Total for injuries	248.38	3.39	2.28	8.54	291.13	3.49	2.40	9.39	302.30	2.64	7.04	9.76	252.67	3.39	2.33	8.64
Total for all causes	1,254.15	19.72	7.12	40.34	1,313.43	19.97	8.45	38.92	1,190.41	24.21	16.72	40.03	1,258.89	19.78	7.32	40.26

(a) For 1887-95—nine years of decade; (b) for 1891-95—four years of decade.

B.—Table Showing the Average Strength, Admissions into Hospital, Deaths, Numbers Invalided and Constantly Sick among the British Troops Stationed in the United Kingdom during the Year 1897, with the Ratios per 1,000, the Strength, and the Average Ratios for Ten Years.

Average Strength in Annual Returns, 96,526. Average Strength, Including Men Detached, 98,290.

Diseases.	Admission to hospital.	Deaths.			Invalids discharged from the service.	Average number of constantly sick.	Ratio per 1,000.				Average Ratio per 1,000 from 1887 to 1896.			
		With the regiment.	Absent from the regiment.	Total.			Admissions.	Deaths.	Invalids finally discharged.	Constantly sick.	Admissions.	Deaths.	Invalids finally discharged.	Constantly sick.
General Diseases.														
Smallpox	....	..	..	..	....	.....	....	....	....	....	0.1	....	....	0.01
Other eruptive fevers	1,057	10	..	10	....	92.43	11.0	0.10	....	0.96	8.6	0.06	....	.65
Influenza	591	..	..	..	....	17.25	6.1	....	....	.18	16.1	.03	....	.44
Diphtheria	44	4	..	4	....	2.37	.5	.04	....	.02	.7	.02	....	.05
Enteric fever	88	20	1	21	....	15.11	.9	.21	....	.16	1.3	.25	....	.21
Other continued fevers	360	1	..	1	....	13.59	3.7	.01	....	.14	4.1	.01	....	.15
Cholera	....	..	..	..	....	.05	....	....	....	....	....	....	....	....
Dysentery	47	1	..	1	5	4.15	.5	.01	.05	.04	.6	.02	.04	.06
Yellow fever	....	.	..	..	....	......	....	....	....	....	....	....	....	....
Malarial fever	500	2	..	2	1	19.27	5.2	.02	.01	.20	6.1	.01	.02	.22
Septic diseases	54	3	..	3	....	3.69	.6	.03	....	.04	1.8	.08	....	.12
Tuberculous diseases	236	45	6	51	142	40.92	2.4	.52	1.44	.42	3.8	.85	1.91	.60
Syphilis, primary	3,218	..	..	..	....	327.42	33.3	....	....	3.39	59.2	....	.01	5.60
Syphilis, secondary	2,919	5	1	6	102	316.11	30.2	.06	1.04	3.27	35.9	.05	.87	3.55
Gonorrhœa	6,176	..	..	..	16	464.99	64.0	....	.16	4.82	86.2	....	.05	5.88
Hydrophobia	....	..	..	..	....	......	....	....	....	....	....	....	....	....
Parasitic diseases	2,277	1	..	1	....	73.75	23.6	.01	....	.76	26.3	....	....	.74
Scurvy	1	..	..	..	....	.02	....	....	...	....	.1	....	....	...
Alcoholism	158	2	..	2	....	5.33	1.6	.02	...	.06	2.2	.03	.01	.07
Rheumatism	2,515	7	..	7	63	167.57	26.1	.07	.64	1.74	34.6	.05	.64	2.19
Debility	654	..	..	..	90	49.19	6.8	....	.92	.51	7.2	.01	.90	.50
Other general diseases	544	11	..	11	42	36.56	5.6	.11	.42	.38	5.2	.12	.19	.35
Local Diseases.														
Diseases of the nervous system: Nervous	623	17	2	19	125	48.09	6.5	.19	1.27	.50	7.2	.30	1.13	.49
Diseases of the nervous system: Mental	121	2	..	2	86	18.30	1.3	.02	.88	.19	1.3	.02	.90	.23
Eye	1,066	..	..	..	85	65.66	11.0	....	.87	.68	11.4	....	.69	.69
Other organs of special sense	908	2	..	2	142	63.81	9.4	.02	1.44	.66	7.8	.01	.85	.50
Circulatory system	1,053	31	4	35	368	104.68	10.9	.36	3.74	1.08	9.9	.37	3.50	.96
Respiratory system	4,435	51	4	55	73	229.37	46.0	.56	.74	2.38	60.2	1.16	.81	3.02
Digestive system	9,085	17	1	18	179	305.83	94 1	.18	1.82	3.17	105.7	.32	.98	3.20
Lymphatic system	956	..	..	..	14	105.93	9.9	....	.14	1.10	15.8	.01	.12	1.70
Urinary system	186	11	1	12	37	19.96	1.9	.12	.38	.21	2.2	.14	.27	.20
Generative system	2,330	1	..	1	38	162.19	24.1	.01	.39	1.68	34.2	.01	.29	2.24
Organs of locomotion	1,239	2	..	2	197	89.10	12.8	.02	2.01	.92	8.3	.02	1.06	.65
Connective tissue	2,350	1	..	1	6	101.92	24.3	.01	.06	1.06	23.6	.01	.08	1.05
Skin	5,029	..	..	..	28	222.47	52.1	....	.29	2.30	46.3	....	.21	2.01
Injuries.														
General	35	27	..	27	2	2.86	.4	.28	.02	.03	.2	.35	.01	.01
Local	10,616	35	1	36	110	457.86	110.0	.37	1.12	4.74	98.5	.32	.73	4.06
In action	....	..	..	..	....	......	....	....	....	....	....	....	....	....
Poisons	14	6	..	6	2	.97	.1	.06	.02	.01	.1	.05		.01
No appreciable disease	356	..	..	..	....	14.19	3.7	....	....	.15	3.1	....	....	.10
Cause unknown (refers to death only)	....	..	..	..	....	......	....	....	....	....	...	....	....	....
General total	61,841	315	21	336	1,953	3,662.96	640.6	3.41	19.87	37.95	735.9	4.68	16.27	42.51

0.81 per thousand in 1894; while contagious eye inflammations fell from 7.0 to 1.5 per thousand.

Decrease of Rates for the German Army.

Year.	Morbidity per 1,000.	Mortality per 1,000.	Invalided per 1,000.
1879-80	1,174.8	4.82	....
1880-81	1,136.2	4.82	....
1881-82	1,135.5	4.53	....
1882-83	849.6	4.25	20.6
1883-84	830.1	4.16	20.7
1884-85	850.3	3.93	20.4
1885-86	849.2	3.73	23.9
1886-87	808.0	3.79	20.6
1887-88	804.1	3.24	21.5
1888-89	758.9	3.19	19.6
1889-90	897.2	3.30	25.9

According to Boisseau the mortality of the British army on the home station prior to 1853 was 17.5 per thousand strength. After the improvement in the sanitary surroundings of the soldier in that service following the Crimean war, the rates for death and sickness were much diminished, and for the decade 1875–1884 had fallen to 7.20 deaths per thousand strength. In 1889 the death rate was 4.57, the sickness 730.4. In 1890 the deaths rose to 5.53 and the sick rate to 810. For the decade 1887–1896 the admissions were 735.9 and the ratio of deaths per thousand strength was 4.68. In 1897 there died only 3.42 per thousand of strength, while the admission rate had fallen to 640.6 per thousand strength.

The reduction in the rates for sickness and death in the Italian army during the past twenty-five years has been steadily progressive and probably presents less fluctuation than is the case in any other military service.

Year.	Admissions to hospital or infirmary per 1,000.	Death rate per 1,000.	Year.	Admissions to hospital or infirmary per 1,000.	Death rate per 1,000.
1875	1,031	13.3	1887	760	8.7
1876	1,001	11.2	1888	732	8.7
1877	987	10.6	1889	749	8.0
1878	947	10.6	1890	796	7.5
1879	936	9.9	1891	811	9.0
1880	935	11.0	1892	758	7.1
1881	928	10.6	1893	735	6.6
1882	833	10.2	1894	723	5.2
1883	842	11.8	1895	743	7.9
1884	779	11.6	1896	741	5.8
1885	791	10.3	1897	694	4.2
1886	798	9.3			

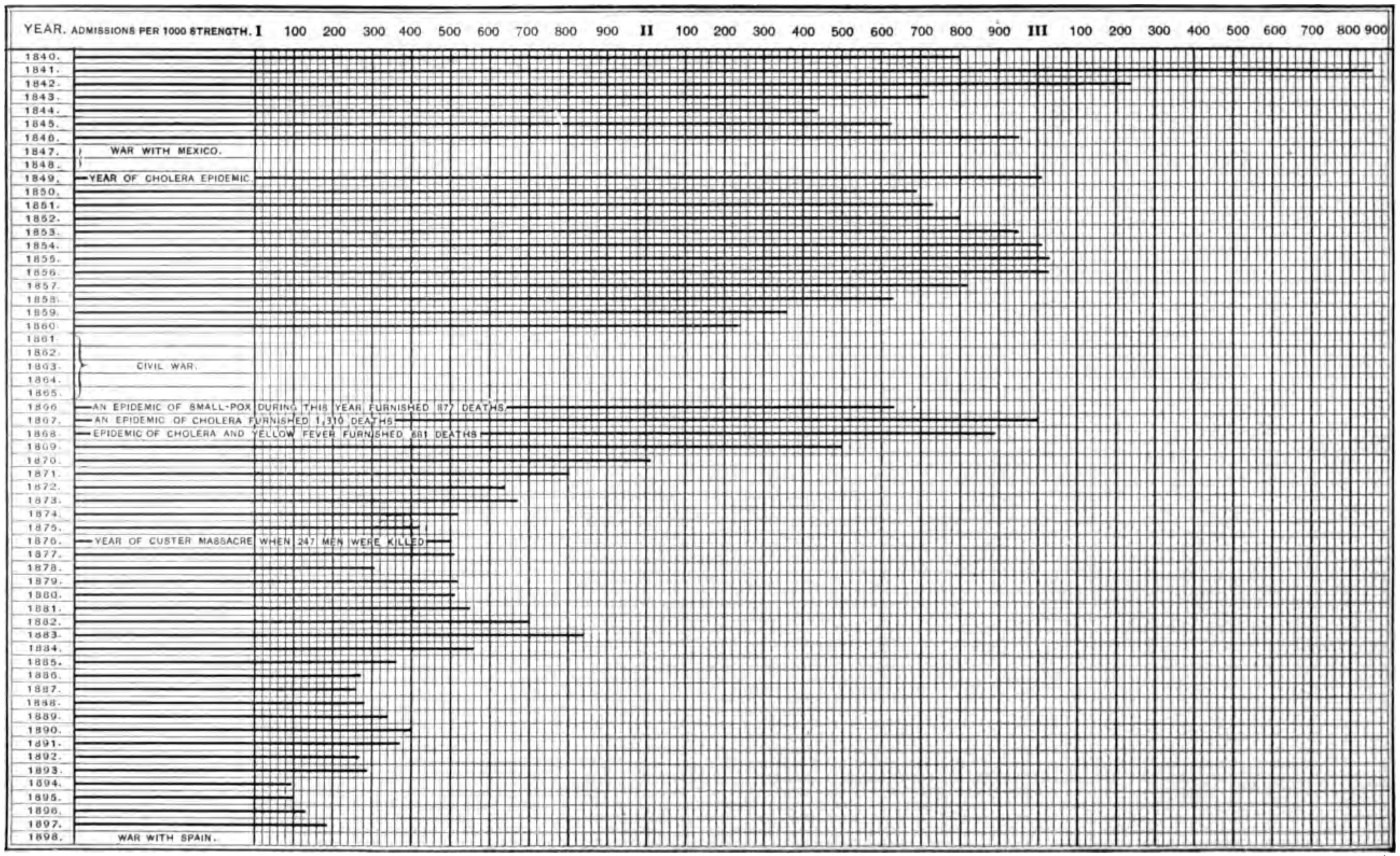


Chart Showing Reduction in the Rate, per Thousand Strength, for Admissions to Sick Report for All Causes, in the United States Army, during Conditions of Peace, for the Period 1840-1898. (The Roman numerals I, II, and III designate each thousand of admissions; the figures 100, 200, 300, etc., show each hundred admissions.)

Viry gives the following rates for mortality in the French army as illustrating the progress of military hygiene:

Period.	Mortality per 1,000 strength.	Period.	Mortality per 1,000 strength.
1812	27.9	1873–81	9.0
1820-25	21.4	1883	8.15
1846	19	1889	5.39
1846–58	16	1890	5.81
1862-72	13		

Dewey states that in the French service the average annual death rate was 8.43 per thousand strength for the seven years 1880–1886, and that it sank to a yearly average of 6.63 for the seven succeeding years. This decreased death rate is naturally consequent to a lessened amount of sickness, as the following figures from Marvaud illustrate:

Period.	1862–1865.	1866–1869.	1884–1887.
Admissions to hospital per 1,000 strength (admissions to infirmaries and cases treated in quarters not included)	264.5	259.5	177.0
Rate of constant non-effectives per 1,000 strength.	23.3	22.1	14.0

Lindley, writing in 1892, states that during the preceding forty years the death rates in the Prussian and Belgian armies had shrunk to two-fifths, the English and Russian rates had fallen to one-half, and the French rate had diminished to one-third. These figures may probably be accepted as being approximately correct.

The lamentable conditions revealed by the above statistics as existing until even within the present generation were undoubtedly largely due to ignorance of first causes of disease, by which measures for its prevention could not be intelligently applied, as well as to an insufficient knowledge of hygiene and lack of appreciation as to its value from a military standpoint. An additional factor of no mean importance, however, was to be found in the former anomalous and inferior condition of the medical officer, his lack of authority to recommend in sanitary matters, and his powerlessness to control or remedy existing conditions. It was long held that his duties were merely to care for the sick and wounded, and any recommendations bearing on the general care or management of the men were deemed intrusive and as such usually disregarded and resented. The comparatively recent conferring of advisary powers upon the surgeon for sanitary purposes has undoubtedly been a potent factor in the gradual betterment of the sanitary condition, and hence efficiency, of the soldier; and when the medical officer is invested with actual authority upon all matters bearing upon the health of troops, with executive powers as well as advisory privileges, a still further improvement in this direction may be expected.

Although during the past one or two generations a marked diminution has occurred in the sickness, mortality, and non-efficiency among the troops of the United States and those of European nations upon the home stations, the same unfortunately cannot be said with regard to white troops doing colonial duty in tropical climates. For them these rates continue to be high, and no great improvement in their sanitary state, as evidenced by statistics, appears to have resulted for many years. Since the hygienic requirements for each military establishment, wherever its troops may be stationed, must be accepted as being the same for all circumstances, the conclusion is obvious that climatic conditions in the tropics furnish a potent obstacle against a constant reduction in rates proportionate to those which have occurred on the home stations. While undoubtedly much has been done during the past generation to render military service in hot countries less inimical to life and health, the fact none the less remains that sanitary progress in the low latitudes has fallen far short of that obtaining in more temperate climates. It is evident that figures illustrating this point are best furnished by the records of the British service, and these are briefly compared as follows:

	Period.	Admissions to hospital per 1,000.	Deaths per 1,000.	Days lost per man.
West Indies	Decade 1875–84.	885.0	15.36	16.26
	Decade 1886–95.	1115.7	9.23	22.67
	Year 1896	1190.2	6.19	28.69
Ceylon	Decade 1875–84.	1085.4	14.51	20.97
	Decade 1886–95.	1004.1	11.38	21.10
	Year 1896	1321.1	8.23	23.76
China	Decade 1875–84.	1030.4	10.53	18.07
	Decade 1886–95.	1256.0	11.44	22.41
	Year 1896	1856.5	7.48	32.05
India	Decade 1875–84.	1482.9	17.43	23.06
	Decade 1886–95.	1453.5	15.52	30.26
	Year 1896	1386.7	15.29	34.35
Egypt and Cyprus	Decade 1875–84.	No fi	gures gi	ven.
	Decade 1886–95.	1069.7	16.30	24.56
	Year 1896	822.3	13.28	23.11
Straits Settlements	Decade 1875–84.	No fi	gures gi	ven.
	Decade 1886–95.	1079.4	7.27	25.58
	Year 1896	1074.7	8.88	26.46

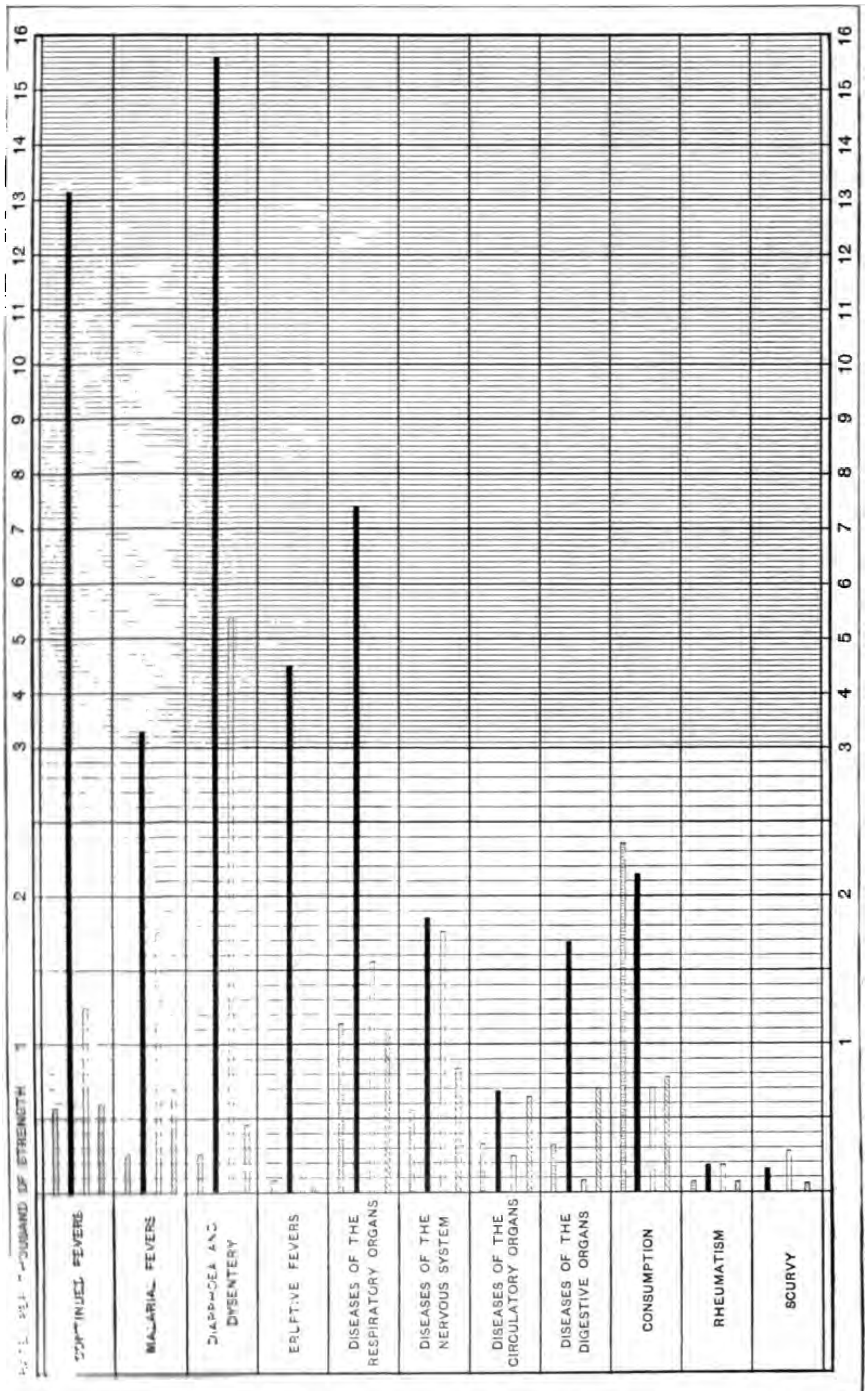
From these figures it is evident that while there was a considerable diminution in the morbidity and mortality rates for the West Indies and Ceylon during the past twenty years, but little improvement has occurred in the general rates for China, Egypt, and Cyprus. In India, a country long occupied by a large military force and one in which the greatest improvement might reasonably be expected to have occurred, the rates are practically what they were two decades ago—the death rate of British troops at home having fallen from 7.20 to 3.58 per thousand, while the same rate for India only fell from 17.43 to 15.29 during the same period. Further, the several rates for the Straits Settlements have actually increased during the past ten years.

In this respect the experience of Great Britain is duplicated by that of the French service: in which in 1862 the mortality for troops throughout France was 9.42 and for those in Algeria 12.21 per thousand; while in 1890 the death rate for troops at home was 5.81 and for those in Algeria 11.94 per thousand.

War as Affecting the Health of Armies.—The rates of sickness and death of troops in campaign, independently of the circumstances which accompany conflict, are chiefly influenced by the standard of hygiene maintained; and, as is stated elsewhere, it is difficult to cite campaigns in which the death rate from sickness has not been greater than that from casualty.

The diseases observed during continued warfare, according to Laveran, are largely brought about by four chief influences: atmospheric, exhalations from the soil, evil condition of the latrines, and poor food. The atmospheric exposure to which the soldier is often subjected is one of the greatest hardships of a campaign. Sleeping on the bare ground and often drenched with rain, standing in trenches exposed to snow and cold, or making long marches under a tropical sun, are a few of the influences by which he is debilitated and his constitution impaired. Service in a malarious country is notoriously productive of disease, while illy-policed sinks are potent factors in the occurrence of typhoid and dysentery. The influence of insufficient or improper food in lowering the resisting powers of the soldier is well recognized. Excessive fatigue and moral influences also play an important part in determining the sick rate, it being well established that victorious forces have less sickness than armies which have been beaten and demoralized. The endemic and epidemic diseases of an occupied country, together with the influence of a change of climate, aggravate also to a considerable degree the sickness and mortality of an expeditionary corps.

For our own service the influence of hostilities upon mortality from disease is well illustrated in the accom-



A Comparison of the Annual Mortality Rates Caused by Certain Diseases in Various Groups of Men of the Military Age.

United States civilians — *United States army before the civil war*

United States army during the civil war — *United States army after the civil war*

(Adapted from the "Medical and Surgical History of the War of the Rebellion.")

panying chart (p. 508), showing, as it does, the rates for certain affections in the United States army, during the civil war, for periods before and subsequent to that war, and also as compared with the death rates for the corresponding class in civil life. As compared with the mortality from continued fevers—which affections may be considered, in the light of present knowledge, as of typhoid nature—war brought about an increase of tenfold. Malarial diseases were doubled and diarrhœa and dysentery tripled. Deaths from eruptive fevers became about twenty-two times as frequent as they were before the war, while those from diseases of the respiratory organs were more than quadrupled. Camp life appeared to have little influence in affecting the mortality from nervous affections. Deaths from diseases of the circulatory and digestive organs were practically doubled in frequency, as was also the mortality from consumption. Rheumatism, as regards a fatal termination, and contrary to expectation, was not increased; but scurvy—the former bane of armies in the field—was doubled. The average annual death rate from disease during the entire war was 53.48 per thousand strength among white troops, while it was 18.98 for these troops during the eighteen years before the war, excluding the two years of hostilities against Mexico, and somewhat over 6 per thousand for the decade subsequent to the war.

The following table shows the influence of the war with Spain upon the rates for sickness and death, as regards the prevalence of certain classes of diseases:

progress of disease, by months, is quite dissimilar. It is particularly noticeable that not only was the death rate during the war with Spain reduced by 43.9 per cent. as compared with the struggle of the previous generation, but the amount of epidemic typhoid, largely resulting from the inexperience of the volunteer troops, rapidly decreased as a result of scientific sanitary measures enforced as soon as the magnitude of the typhoid outbreak was fully understood.

COMPARISON OF MONTHLY DEATH RATES (PER 1,000) FROM DISEASE.

Months.	1861-1862. Mean strength	1861-1862. Number of deaths.	1861-1862. Ratio per 1,000 of M.S.	1898-1899. Ratio per 1,000 of M.S.	1898-1899. Number of deaths	1898-1899. Mean strength.
May	16,161	18	1.11	0.26	42	163,726
June	66,950	55	.82	.44	90	202,526
July	71,125	106	1.49	1.72	451	262,613
August	112,359	242	2.15	5.21	1,400	268,507
September	165,126	365	2.21	5.89	1,541	261,824
October	256,884	725	2.82	3.17	809	255,000
November	301,848	1,145	3.79	1.51	365	242,000
December	343,184	1,471	4.29	.84	201	240,000
January	352,760	1,593	4.52	.85	180	211,000
February	327,734	1,346	4.11	.87	156	180,000
March	328,878	1,575	4.79	.90	123	136,000
April	410,416	1,881	4.58	.71	80	113,000
Annual	229,452	10,522	45.86	25.73	5,438	211,350

As already intimated, so many factors combine to determine mortality from sickness in campaign that any attempt at the close comparison in this respect of different wars—carried on under entirely different conditions—can yield only misleading results. General deductions can of course be drawn, and hence the following figures may be of advantage as well as interest:

TABLE GIVING FIGURES FOR THE COMPARISON OF THE YEAR OF PEACE, 1897, WITH THE YEAR OF WAR, 1898.

Group.	Admissions per 1,000 Strength. 1897.	Admissions per 1,000 Strength. 1898.	Constantly Non-Effective per 1,000 Strength. 1897.	Constantly Non-Effective per 1,000 Strength. 1898.	Deaths per 1,000 Strength. 1897.	Deaths per 1,000 Strength. 1898.	Discharges for Disability per 1,000 Strength. 1897.	Discharges for Disability per 1,000 Strength. 1898.	Total Losses per 1,000 Strength. 1897.	Total Losses per 1,000 Strength. 1898.
Infectious diseases, general and local	326.10	1,034.97	12.59	57.90	1.35	15.99	1.28	2.14	2.63	18.13
Diseases of nutrition	2.05	3.49	.19	.21	....	.09	.29	.13	.29	.22
Diseases of the nervous system	56.94	52.81	1.63	1.33	.33	.92	1.79	.86	2.12	1.78
Diseases of the digestive system	244.05	505.71	3.75	7.01	.55	3.11	.55	.58	1.10	3.69
Diseases of the circulatory system	4.68	6.73	.41	.60	.37	.49	.95	.96	1.32	1.45
Diseases of the respiratory system	77.74	144.50	1.64	2.04	.22	.96	.40	.26	.62	1.22
Diseases of the genito-urinary system	9.76	11.77	.80	.67	.22	.24	.44	.43	.66	.67
Diseases of the lymphatic system and ductless glands	2.36	3.22	.17	.17	.04	....	....	.02	.04	.02
Diseases of the muscles, bones, and joints	72.52	77.34	2.85	2.70	....	....	.31	1.33	1.31	1.33
Diseases of the integument and subcutaneous connective tissues	72.55	60.57	1.70	1.06	....	.30	....	.04	....	.34
Diseases of the organs of special sense	24.47	17.39	.92	.79	.04	....	.58	.62	.62	.62
Unclassified	2.44	19.17	.09	.59	.04	....	....	.02	.04	.02
Total for diseases	896.53	1,937.74	26.73	69.09	3.14	24.94	7.60	7.40	10.74	32.34
Total for injuries	290.08	209.23	9.12	13.74	1.97	8.41	2.01	4.18	3.98	12.59
Total for all causes	1,186.61	2,146.94	35.85	82.83	5.11	33.35	9.61	11.58	14.72	44.93

All things being considered, it is safe to assume that the outbreak of hostilities will be followed by a vast increase in the death rate, probably from six to twelve or more times that normally occurring in peace; the proportion naturally varying with the character of the campaign, the climatic conditions to be encountered, the local diseases to be undergone, the efficiency of the commissary and transportation departments, the employment of seasoned or unseasoned troops, and many other factors. The rate of admissions to sick report from disease in time of war is not, however, increased proportionately to the death rate—a fact sufficiently proving the more serious nature of diseases when affecting troops in the field. As to the rate for non-efficiency, this is largely dependent upon the ratio for admissions, and naturally bears in its fluctuations a close relationship to the prevalence and character of disease. If the records of the Spanish-American war be accepted as typical in this respect, no great difference in the rates for discharge by reason of disability, in peace or war, may be anticipated. (See chart, p. 510.)

In comparing the results of the Spanish-American war with the corresponding period of the civil war the advantage is much in favor of the former, although the

DEATHS FROM DISEASE DURING CERTAIN WARS OF THE PRESENT CENTURY. (After Bradford.)

Name of War.	Nation.	Year or period.	Mortality from disease per 1,000 strength.
Walcheren expedition	Great Britain	1809	346.9
West Coast of Africa	Great Britain	1824	690.0
Mexican	United States	1846-48	100.0
Crimean	Great Britain	1854	230.0
Chinese	France	1862	118.0
Civil War	United States	1862	40.0
Civil War	United States	1863	60.0
Franco-Prussian	Germany	1870-71	18.6
Cape Coast	Great Britain	1873	173.0
Afghanistan	Great Britain	1878-80	93.7
Egypt	Great Britain	1882	72.1
Soudan	France	1883-86	280.0
Madagascar	France	1895	300.0
Chino-Japanese	Japan	1895	14.8
Spanish-American	United States	1898	25.0

With regard to the results of campaigning under tropical conditions, the most satisfactory data are naturally furnished by the two great colonizing powers, Great Britain and France. The figures given for these services are, however, so widely dissimilar as to furnish no foundation for any general conclusions based upon them both. For purposes of comparison merely, they are certainly valuable; the French having little reason to be proud of their sanitary showing.

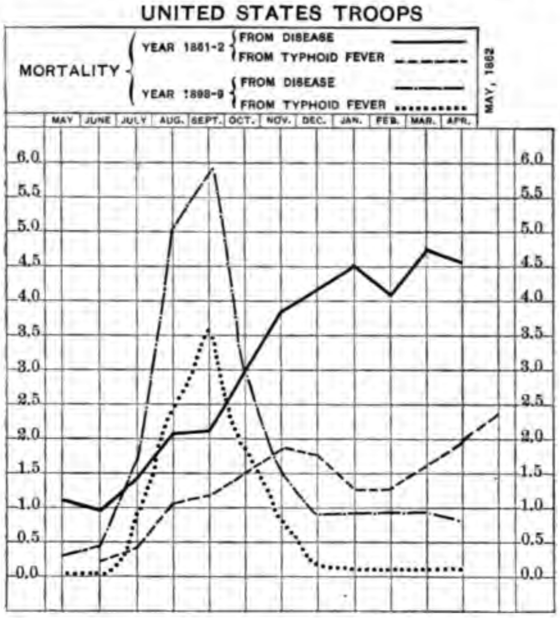


FIG. 283.—Mortality from All Diseases and from Typhoid Fever during the War with Spain and during the Corresponding Period of the Civil War. (After Sternberg.)

TABLE OF MORTALITY FROM DISEASE IN CAMPAIGNS IN TROPICAL COUNTRIES, SHOWING RATE OF DEATH PER 1,000 STRENGTH. (After Bradford.)

British Expeditions.			French Expeditions.		
Soudan	1889	0.6	Tonkin	1884	60.0
Mashonaland	1876	2.0	Tunis	1881	61.0
Suakim	1885	2.2	Mexico	1862–63	71.0
Soudan	1885–86	4.1	Tonkin	1885	79.0
China (Talien-wan)	1860	5.4	Dahomey	1893	87.0
			Tonkin	1886	99.0
Ashanti	1895–96	5.6	Tonkin	1887	106.0
Egypt	1882	5.7	Cochin-China	1863	107.0
Abyssinia	1867–68	12.1	Soudan	1887–88	116.0
Galeika Gaika	1877–78	14.0	Cochin-China	1862	117.0
China Field Force	1860	14 9	China	1862	118.0
Matabeleland	1896	16.5	Tonkin	1888	133.0
Ashanti	1874	17.4	Soudan	1885–86	200.0
Zululand	1879	24.8	Soudan	1886–87	220.0
Chitral	1895	25.1	Soudan	1887–88	225.0
Nile	1884–85	26.4	Soudan	1888–89	280.0
Dongola	1896	46.6	Madagascar	1895	300.0
Afghanistan	1878–80	93.7			

The casualties of the French expedition in Madagascar are thus given by Gayet:

Killed by the enemy	7
Wounded	94
Deaths from sickness	5,600
Sick, more than 15,000, or 85 per cent. of the whole.	

From the above table it will be observed that with the exception of the Afghanistan campaign, in which the high mortality was largely the result of an outbreak of cholera, the most unhealthful of seventeen English expeditions in warm climates had a lower death rate than the healthiest of an equal number of French campaigns under presumably similar climatic conditions. The British expedition against the Ashantis, in 1874, certainly demonstrated the efficiency of military hygiene under notoriously unhealthful conditions; and, in the excellent results obtained, the second expedition against this same tribe, in 1896, even surpassed the first. In our own expedition against Manila, during the war with Spain, the results were admirable, only 8 per thousand dying from disease. During the Cuban insurrection the Spanish are reported, for the year 1897, to have had a death rate of 86 per thousand from all causes. The admissions to hospital for the same period were 1,900 per thousand, of which 420 per thousand were for malaria. During 1897 the Spanish troops appeared to have suffered but little from yellow fever; this being probably due to an immunity to this disease acquired through previous visitations.

That constant exposure to infectious disease of all kinds, and not only yellow fever, does actually exert a seasoning influence on the survivors and reduce their mortality is well known. As illustrating this point, it may be noted that the sick rate of colored troops during the civil war fell from 4,092 per thousand during the first year of their service to 2,797 in the last, while their death rate dropped from 211 to 94 per thousand strength. The total rates for sickness during the civil war underwent considerable diminution, as follows:

First year, admissions per 1,000 strength	2,983
Second year, admissions per 1,000 strength	2,696
Third year, admissions per 1,000 strength	2,210

In this connection the chart already given in the section showing the influence of race as affecting the prevalence of disease is of interest.

It is not, however, during active wars or on expeditions that the highest mortality is observed among troops in the field. When an army is condemned to inaction through a siege, for purposes of mobilization, or even in cantonments after a laborious expedition, sickness rages with the greatest violence. The typhus that tried the Crimean army occurred in the winter after the capture of Sebastopol and after conclusion of the armistice; and examples might be indefinitely multiplied in our own service to show that the stationary force, during war, is an unhealthy force. In January, 1862, the medical director of the Army of the West, then in winter quarters, reported 13.5 per cent. of the total strength as being excused from duty, and a little over 12 per cent. in March of the same year. In August, 1861, of some troops encamped on the Arlington flats on the Potomac, 33 per cent. were reported sick with diarrhœa and malarial fever. During the war with Spain the typhoid epidemics, as is well known, occurred in the large fixed camps. An excellent instance is found in the condition of the French troops during the Crimean War, a struggle from which so many sanitary lessons have been drawn. According to Rawlinson, reliable estimates as to the sickness among these troops, for the winter of 1854–55, were as follows:

Month.	Strength.	Sick in hospital.
October	46,000	3,200
November	55,000	5,000
December	65,000	6,000
January	75,000	9,000
February	88,000	8,000

These figures do not include the sick treated in regimental infirmaries or in the hospitals at Constantinople.

Comparison of Military Statistics.—It is a matter of the greatest difficulty, if not indeed impossible, accurately to compare the sanitary conditions of various armies, since

their statistical tables are often differently constructed, the physical requirements for recruits are not identical, and diverse regulations as to discharges for disability prevail.

In attempting to institute such comparisons it is well to appreciate at the outset that a sick rate can be kept low by excluding the doubtful or milder cases from the benefits of quarters or hospital, and so preventing them from appearing on the official records; that the sick rates, mortality, and constant non-efficiency can be held down by a searching system of discharge for disability, and that the total loss—as shown by the sum of the rates for death and discharge—is, in determining the sanitary state of an army, of much more importance than either of its complementary factors.

In comparing the rates of our service with those of foreign armies the admission rate is the one which, by its magnitude, attracts attention. This higher rate of admissions, however, does not in itself imply a greater prevalence of disease among the troops of the United States; since with us, in contradiction to the practice in other armies, the soldier is officially taken on sick report whenever he is excused by the medical officer from any part of his duty, whatever be the cause. When it is observed, as was the case in the year 1888, that 796.89 admissions per thousand strength from the Italian army resulted in a death rate of 9.31, while 1,270.73 admissions for each thousand United States troops for the same period—divided into 621.61 cases admitted into hospital and 649.12 treated in quarters—had a mortality of only 8.15 per thousand, it is evident that the admissions in the two instances—the rates for discharge for disability not varying greatly—do not constitute facts of equal gravity and are therefore not available for comparison.

The rate for constant non-efficiency is obviously largely dependent upon the admission rate and that of discharge for disability, and reflects, to a considerable degree, their variations. Taken by itself the rate is misleading, and it acquires a certain value only when considered in connection with other rates, particularly that for admissions. As between services, for the reasons already given, it is evident that non-efficiency rates are not susceptible of proper comparison.

The death rate alone, as a means of comparison between several armies, is wholly unreliable and merely productive of error; since, as above stated, it can be markedly reduced by the removal from the service of those subject to or predisposed to disease.

Of all the ratios which go to determine the healthfulness of an army, as shown by statistics, that giving the discharge for disability is of the greatest importance. In its relation to military morbidity it is at once evident that the admissions to hospital will be largely furnished by the physically less sound, and that a prompt and proportionate diminution in the sick rate must follow the elimination of these weaklings by their discharge from the service. In addition, the number of men withdrawn from the aggregate strength of the command, the rate of non-effectiveness from disease or injury, is not a factor of equal importance in all armies and cannot be justly used for purposes of comparison. It undoubtedly embodies the number of admissions and the gravity of the cases so admitted; but it is obvious that the constant non-efficiency as well as the admission rate varies inversely with the rigor of the system of discharge. As to mortality, this too depends upon the physical standard maintained, and, as shown in the German army, a low death rate is naturally consequent to the early elimination of those soldiers who are predisposed to or actually affected with disease. Hence the rate of discharge for disability is the controlling factor in the determination of the rates of admissions, deaths, and constant non-efficiency; while it is itself largely dependent upon the physical standards to which the recruit, before enlistment, is required to conform. To institute accurate comparisons, therefore, a constant, unvarying standard for discharge for disability should obtain in the several military forces to be compared; and such a constant standard does not—and practically cannot—exist. Requirements as to discharge for disability necessarily vary with the customs of each military service, and, to a certain degree, with the personal equation of each medical officer. As an instance of the former, it may be noted that the Germans are especially assiduous in promptly removing the tuberculous from their armies; we, on the other hand, maintaining a sanitarium for soldiers affected with this disease; and this single source of error, to which might be added many other less aggravated instances, prevents a comparison of sick rate, mortality, and non efficiency upon anything like equal premises. If it be admitted, however, that the physical requirements for the recruits of various armies are approximately the same, the total losses, irrespective of either non-efficiency or admission rate, should afford a somewhat inaccurate, but still the most available and satisfactory method of determining the comparative health and physical efficiency of various services.

The following figures, taken from Marvaud, show the annual sick rates, mortality, loss by discharge, and total losses in various European armies for a period about ten or twelve years ago:

Name.	Year or period.	Admissions to hospital or infirmary per 1,000 strength.	Death rate per 1,000 strength.	Discharges for disability per 1,000 strength.	Total losses per 1,000 strength.
Belgium	1887-88	338 *	3.9	17.0	20.9
Austria	1887	995 †	6.9	15.0 ‡	21.9
Great Britain (home stations)	1884-85	877	5.2	20.0	25.2
France (home stations)	1888	500	6.1	21.0	27.1
Germany	1883-84	849	3.9	29.0	32.9
Italy	1887	760	8.7	28.0	36.7
Russia	1880-84	845	8.9	31.3	40.2
Spain	1886	...	13.5	30.8	44.3

* General hospitals only. † Including detention in barracks. ‡ Not including temporary invalids.

During the year 1888 the total admissions per thousand strength in the United States army amounted to 1,270.73, the deaths were 8.15 per thousand, the constantly non-effectives were 41.91 per thousand, the discharges for disability 27.75 per thousand. These figures give a total annual loss of 35.90—thus making our sanitary showing for that time inferior to that of the above-named nations except Italy, Russia, and Spain; all countries notoriously the least advanced in matters pertaining to hygiene. It can, however, scarcely be believed that our men, under equal conditions of selection, broke down nearly twice as readily as the Belgian or Austrian soldiers and half again as rapidly as the British soldiers, and hence the conclusion would seem to be inevitable from the above figures that our troops were at that time examined on enlistment with a laxity as to their physical condition which did not obtain in foreign services. This idea is further strengthened by the fact that during the same year (1888) out of 742 men discharged on certificates of disability, in 129 instances the disability was specifically declared to have existed prior to enlistment. About this time the large number of discharges for disability attracted the attention of the authorities, and recruiting officers were warned to be more strict in their examinations for enlistment; while a general order required that all men recommended for discharge on account of disability be sent to the headquarters of each military department for observation by the chief surgeon pending final action in their cases. As a result of these requirements the rates for discharge were decreased by nearly one-half in a single year, since which even further diminution has taken place. For the year 1897 the rate for discharge on account of disability was only 9.61 per thousand as compared with 27.75 during 1888. On comparing the statistics of the above armies for a more

recent period—excluding France and Spain, for which countries no later figures are obtainable—the relative status of the United States service is found to be as follows:

Country.	Year.	Admissions to hospital or infirmary per 1,000 strength.	Death rate per 1,000 strength.	Discharges for disability per 1,000 strength.	Total losses per 1,000 strength.
Germany	1895	819.0	2.6	9.0	11.6
Belgium	1897	429.3	2.0	12.4	14.4
United States	1897	1,186.61	5.11	9.61	14.72
Great Britain (home stations)	1897	640.6	3.42	19.87	23.29
Italy	1897	694.0	4.2	21.2	25.4
Russia	1896	314.6	5.40	24.9	30.30
Austria	1897	332.7	4.0	37.5	41.5

It is evident from the above that much has been accomplished during the past decade toward improving the sanitary condition and effectiveness of our army, and it is safe to assume that at the present time the United States soldier is better cared for than is the man-at-arms of nearly every other military service.

Although, as stated, attempts at the comparison of statistics of different armies are at best necessarily inaccurate and unsatisfactory, within the limits of the same service such action is both feasible and desirable: the standard for the health of an army, as expressed by Smart, being its own best annual record. Outside of unusual vicissitudes, exposure, and epidemics, and of the unsanitary conditions which bring disease and death into the ranks of a military command during campaign, the sanitary surroundings of the soldier do not vary much from year to year except as they are modified by intelligent efforts for their improvement. What has been accomplished in the past should therefore be effected in the present; or satisfactory explanation should be given of the cause of failure, which would thus be converted into a source of protection for the future.

As to military rates as affected by the geographical distribution of troops, the following table shows the relative sickness among the forces stationed in the various military departments within the limits of the United States during the year 1897:

Department.	Annual death rate per 1,000 strength.	Annual discharge rate per 1,000 strength.	Duration of treatment among patients who died.	Duration of treatment among patients who were discharged for disability.	Average number of sick daily.	Average duration of treatment.	Total losses by death and discharge for disability.	Admission rate per 1,000 strength.	Constantly non-effective per 1,000 strength.
East	5.61	5.85	17.80	83.40	287.28	10.38	11.46	1,260.04	35.83
Missouri	5.30	6.91	16.78	86.06	157.36	11.13	12.21	1,188.89	36.25
Dakota	4.77	9.55	28.17	109.54	85.28	12.70	14.32	975.33	33.93
Platte	7.27	4.59	22.37	119.67	96.61	10.43	11.86	1,294.41	36.99
Texas	6.24	7.38	5.27	100.38	69.88	9.51	13.62	1,522 14	39.65
Colorado	3.56	13.93	73.45	115.81	110.07	10.21	17.49	1,274.05	35.66
California	3.15	6.30	24.40	66.40	41.81	11.81	9.45	813.60	28.33
Columbia	6.20	10.33	36.56	75.47	37.25	11.94	16.53	788.44	25.65

From the above it is seen that the Department of California is the most healthful, with the Department of the Columbia and Dakota closely following. The Department of Texas has long been recognized as the most unhealthful military division.

The statistics for the entire British army in time of peace are of particular importance, covering as they do a large number of geographical divisions under diverse climatic conditions and enabling the making of accurate comparisons through the similar sanitary, military, and administrative conditions prevailing throughout the whole. The figures for that service, for the ten years 1887 to 1896, are given below.

RATIO PER 1,000 STRENGTH.

European Troops.	Admitted.	Died.	Sent home as invalids.	Discharged as invalids.	Constantly non-effective from sickness.	Average sick time to each soldier.	Average duration of each case of sickness.
						Days	Days
Troops at home and abroad	997.4	8.81	23.65	14.52	58.57	21.38	21.47
United Kingdom	735.9	4.68	....	16.27	42.51	15.52	21.04
Gibraltar	708.8	4.01	15.23	8.25	46.65	17.02	24.01
Malta	666.9	7.53	19.20	10.53	44.29	16.17	24.25
Egypt and Cyprus	998.8	11.08	19.04	12.09	65.48	23.90	23.93
Canada	499.1	4.37	14.34	11.90	25.54	9.32	18.68
Bermuda	559.2	10.07	12.65	8.14	29.58	10.80	19.31
West Indies	1,119.3	8.43	20.23	13.40	64.48	23.54	21.08
West Africa *	2,652.7	45.02	237.94	12.86	84.89	30.98	11.68
South Africa and St. Helena	868.3	6.63	23.97	14.54	55.85	20.39	23.48
Mauritius	1,364.4	15.04	55.94	17.42	73.76	26.92	19.37
Ceylon	1,028.0	11.10	20.35	11.42	58.29	21.27	20.69
China	1,324.7	11.31	33.34	14.28	64.97	23.71	17.91
Straits Settlements	1,072.1	6.73	18.14	9.27	72.48	26.46	24.68
India	1,443.9	15.50	25.17	13.24	84.87	30.98	21.45
On board ship	1,132.8	6.41					

* For eight years only, 1889 to 1896.

It is readily seen that the total losses vary from the minimum of 12.26 per thousand at Gibraltar to the maximum of 57.88 on the west coast of Africa; while the death rate of troops at home is only about half that of the entire army. The discharges for disability in the latter instance are slightly higher, the constant non-effective considerably lower, as is also the number of days lost by each soldier.

The mortality among the European troops of the French army on foreign service per thousand strength is, according to Gayet, thus proportioned among the following stations:

Algeria	11 to 12
Antilles	18 to 22
Senegal	about 73
Réunion before the Madagascar expedition	28 to 30
Réunion after the Madagascar expedition	80 to 90
New Caledonia	9 to 10
Cochin China	22 to 24
Tonkin	about 75

While statistics with regard to our own troops on foreign service are not as yet available, it is probable that they will not greatly differ from the rates of the British troops at the nearest of the tropical stations noted above.

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ARMY NURSE CORPS.—In the days of peace, between the civil and the Spanish wars, nursing in the army was done entirely by men. At the end of March, 1898, there was a body of 520 hospital corps men in all degrees of training as nurses for army work, as well as 208 hospital stewards and acting stewards who may be considered the equivalents of graduate nurses in civil hospitals. This number, barely adequate for an army of 25,000 men in time of peace, was, of course, wholly inadequate in time of war for an army of ten times that size, and although it was planned greatly to increase the hospital corps, it was evident that the raw material obtainable could not do the work of trained nurses. Therefore, to supply the approaching necessities of the army, the United States Congress, in April, 1898, at the request of the surgeon-general, authorized him to employ nurses under contract and made an appropriation for their payment. No restriction was made as to sex, but at that time it was the opinion of the War Department that but few women nurses would be needed and that their services would be limited to the general hospitals. Several hundred women, largely untrained, had already applied, but the force of the surgeon-general's office was too limited to permit of any examination of their qualifications.

Knowing these facts, the writer suggested to the National Society of the Daughters of the American Revolution (of which she was a vice-president-general) that that organization should act as an examining board on women nurses for the Government. The surgeons-general of both the army and navy promptly accepted this offer of the Daughters, and in April the "D. A. R. Hospital Corps" was organized, with the writer as director.

The standard adopted for appointment to army service was that of graduation from a training school, combined with suitable indorsements, the chief reliance being placed on a recommendation from the superintendent of nurses under whom the applicant had graduated. Women physicians were also considered eligible, although but few were appointed.

The first nurses were appointed on the 10th of May, 1898, and ordered to the general hospital at Key West, and before the 15th of July, forty-seven nurses had been asked for by surgeons at different general hospitals and had been selected by the "Daughters" for appointment by the surgeon-general. About this time yellow fever appeared among the Santiago troops, and nurses were urgently needed there. The surgeon-general, therefore, employed the wife of the superintendent of a Washington hospital and sent her to New Orleans to secure the services of immunes, both male and female. The majority of the nurses so appointed were colored women without hospital training, a considerable number of whom were sent to Santiago in July and August. The "Daughters" also supplied a few trained immune nurses for this service.

During the month of August an epidemic of typhoid fever broke out in the camps which had been established as temporary places of instruction for the volunteer troops. It also became evident at that time that these camp hospitals had lost their original character and become practically stationary, and consequently the objection to the employment of women nurses in them had disappeared. During that month, therefore, and especially in its latter half, the demands for women nurses grew to an entirely unexpected amount, and the roll of army nurses reached about a thousand names. Not only did they go to general and field hospitals, but whenever the surgeon in charge of a division or post hospital so requested, trained nurses were assigned to duty under him. During the fall it became not uncommon for regiments or larger divisions of troops, when they moved to Southern camps or to Cuba, to take with them the trained nurses attached to their hospitals, and no inconvenience or difficulty has been reported as having ensued.

It is needless to refer to the great value of the work rendered by these trained assistants to the medical department of the army, since surgeons, patients, and the public at large have been most enthusiastic in their expressions of appreciation. There was scarcely a training school in the United States which did not send some of its best representatives for this work, and the women adapted themselves to camp conditions and to many sorts of discomfort in a manner that quite altered many preconceived opinions.

During the greatest stress of the work valuable assistance in securing the services of nurses was rendered to the government, through the "Daughters," by a number of organizations. The Sisters of Charity merit prominent mention in this connection, as they furnished from their order two hundred Sisters, many of whom had much hospital experience. A few of the Sisters from four other Catholic organizations and from one Protestant Episcopal Sisterhood also served for a time. The Society for the Maintenance of Trained Nurses, which was Auxiliary No. 3 to the American National Red Cross Relief Committee of New York, in August, and for a month or two thereafter, examined the credentials of a large number of applicants, and certified to their having conformed to the standard established by the "Daughters." This society was unique in its work of furnishing money for the transportation of many nurses and for their comfort while waiting orders in New York City and while serving at certain army hospitals. Much valuable aid was rendered by the superintendents of training schools, although it is an interesting fact that no organization of trained nurses has rendered any noteworthy assistance. In spite of the overcrowding which had previously been complained of in the nursing profession, there was much difficulty at the time of greatest stress and need in securing enough suitable applicants to fill the demands from the camps. The chief surgeons at Montauk, Jacksonville, Lexington, and San Francisco were therefore authorized to secure women nurses without regard to training, and in this way a few undesirable appointees unavoidably crept in.

In addition to the army nurses temporary help was accepted at a few hospitals from women who were not connected with the medical department. That such should have been the case is much to be regretted, as irregular nurses are not subject to control and discipline and do not hold the same honorable position as do women who have governmental authority for their presence with the army.

As the women who were assisting the government on behalf of the Daughters of the American Revolution, and of the societies which were co-operating with them, held no official positions, their work was necessarily limited to the selection of nurses for appointment. By the end of August, 1898, it became necessary to establish an army nurse corps division of the surgeon-general's office, and Mrs. Anita Newcomb McGee, M.D., was therefore appointed an acting assistant surgeon and assigned to duty in charge of that division.

After the middle of September, at which time about twelve hundred nurses were in service, there was a gradual decrease resulting from the control of the typhoid fever, and later from the mustering out of the volunteer army. At the close of 1898 there were nearly seven hundred women nurses in the army, the largest number at any one place being one hundred with the Seventh Army Corps, near Havana, Cuba. A large number had also been taken to Matanzas and a few to Puerto Principe, Cuba, and many others were scattered through the camps in the Southern States in preparation for possible transfer to that island. About thirty nurses were in the province of Santiago, including the remnant of the untrained immunes sent there in July and August, 1898.

The work of substituting graduate nurses for such of these as were untrained had, however, been well begun. The beginning of the year also found seventy nurses scattered through Porto Rico.

On the first of July, 1899, there were 202 women nurses in service, since which time the number has ranged between 200 and 225. The total number of women who served as army nurses prior to July 1, 1899, was 1,563, and the number of applications at that date had almost reached 6,000.

The mortality among the trained nurses has been extremely small, the deaths numbering only 5. Five of the 250 Catholic Sisters also died, as did 3 of the untrained (immune) nurses. All except two deaths were from typhoid fever.

Side by side with the general improvement of the standard of army nurses, made possible by the reduction in numbers, has gone the organization of the "Army Nurse Corps" as a whole. Under date of November 7, 1898, the first rules governing this body were issued by the surgeon-general. This circular contained barely three pages, and was practically a preliminary draft of rules, which grew and underwent modification with wider experience. The constant changes in the organization of the army itself rendered it impossible to organize at one step its nursing department, but during the winter and spring of 1899 every fact was fitted into its appropriate place as a precedent and guide for rules which were to be of permanent value.

The complete organization circular, after several months of consideration, was finally approved by the Acting Secretary of War on July 20, 1899, and issued as Circular No. 1 from the surgeon-general's office. In this the term "Nurse Corps" was first made official. These rules were reissued, after slight modification, as Circular No. 1, Surgeon-General's Office, March 9, 1900, which reads as follows:

Circular No. 1, Surgeon-General's Office, June 20, 1899, promulgating regulations governing the Army Nurse Corps (female), is amended to read as follows, and is republished for the information and guidance of all concerned:

The nurse corps shall consist of chief nurses, nurses, and reserve nurses.

The surgeon-general may assign female nurses to duty at all army hospitals where the cases treated are of such character as to require the care of trained nurses. Under ordinary conditions not more than two will be assigned to a hospital having less than twenty beds.

A medical officer requiring the services of female nurses at a hospital will make application to the surgeon-general through the chief surgeon (see paragraph on "Transfers").

At each hospital to which nurses are assigned one of them shall be a chief nurse, appointed by the surgeon-general.

Women not under army contract will not be permitted to serve as nurses in army hospitals unless in an unforeseen emergency, and in such case the medical officer in charge of the hospital will immediately report the fact to the surgeon-general for his action.

Appointment.—To be appointed in the army a nurse must be qualified therefor physically, mentally, and morally, as hereinafter provided:

1. She must present a physician's certificate of health on a blank form which will be furnished by the surgeon-general.

2. She must be a graduate from a training school for nurses which gives a thorough professional education, both theoretical and practical, and requires at least two years' residence in a hospital.

3. She must be indorsed by the present superintendent of nurses at the hospital from which she graduated and also by the one under whom she was trained. Blanks for these indorsements will be furnished by the surgeon-general and are to be returned directly to him.

4. She must be a citizen of the United States.

These provisions may be waived in part in the cases of dietists, of immunes to yellow fever, and of nurses who have rendered satisfactory army service during the Spanish-American war.

[Note.—Nurses are not appointed under the age of twenty-five, but in order to receive correct information, it has been found necessary not to publish this rule in the circular. The application card blank, which is furnished all trained applicants, asks the name, address, date and place of birth, color, height, weight, whether single, married, or widow, and other questions, the principal ones being: Are you a graduate of a training school for nurses? If so, what school and what year? What other hospital experience have you had? Have you nursed continuously since graduation? If not, what has been your occupation? What experience have you had in invalid cookery, and have you had yellow fever?]

Term of Service and Annulment of Contract.—When a nurse on the eligible list is appointed for active service, she signs a contract to serve for at least one year, unless sooner discharged.

When appointed, a nurse is considered as on probation regarding her fitness for army duty, and if not found acceptable will be recommended for annulment of contract by the chief nurse. Such recommendation, approved or disapproved by the medical officer in charge of the hospital, will be forwarded to the surgeon-general.

The contract of a nurse will not be annulled at her own request except for good reason, presented in writing and forwarded to the surgeon-general through the chief surgeon.

When a medical officer has more nurses than are needed at his hospital he will report the fact to the surgeon-general, if the hospital is in the United States; otherwise he will report it to the chief surgeon of the department. If the surgeon-general or chief surgeon does not transfer the surplus nurses to another hospital, they will not be granted a leave of absence, but will be ordered to their homes to report to the surgeon-general for annulment of contract. The medical officer requesting or issuing such orders will immediately forward a copy to the surgeon-general, stating in full the reason for his action, and he will also forward the special efficiency report prepared by the chief nurse.

He will indorse on the nurse's contract the date of her departure from the hospital and the date to which she was last paid, and direct her, on arrival home, to forward it to the surgeon-general and report for annulment of contract or orders. All contracts will be annulled by the surgeon-general (or by his order), who will fix the date thereof. A nurse will not be entitled to commutation of rations while awaiting annulment of contract.

If a nurse prefers to have her contract annulled without returning home, no orders will be issued in her case and no transportation will be furnished, as she cannot receive or use transportation orders after annulment.

Pay.—For service in the United States a nurse will be paid $40 a month, and in Cuba, Porto Rico, the Hawaiian Islands, or Philippine Islands, $50 a month.

All chief nurses receive the same allowances as nurses, and where less than five nurses are constantly serving at a hospital, the chief nurse does not receive increased pay. Where five or more, and less than ten, are constantly serving, the chief nurse receives $10 a month more than the nurses. Where ten or more are constantly serving, she receives $25 a month more than the nurses.

Accounts for the pay of nurses under contract will be prepared by the officer under whose direction they may be serving, upon vouchers (Form 4) in duplicate, properly certified by the officer in charge and signed by the nurse and forwarded to a disbursing officer for settlement. No payments to nurses will be made on pay rolls.

Vouchers will be prepared and forwarded at the end of each month, upon the annulment of contract, upon transfer to another station and upon departure on leave of absence or by order; the date of last payment and by whom paid will be stated on each voucher, and upon final voucher the date of annulment of contract.

In preparing vouchers the officer will certify only as

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to time of service and amount due the nurse while said nurse has been on duty at the hospital under his charge; except, that upon the presentation of an order for transfer to said hospital, or a leave of absence from which a nurse has returned (if said leave of absence is with pay), the officer will take up on the voucher and credit the nurse with the amount due for the period covered by said order or leave of absence.

The nurse's copy of her contract will in all cases accompany vouchers when presented for payment, and will be returned to her with the check when received from the disbursing officer.

Disbursing officers will note all payments on the contracts of nurses, and will forward to this office, on information slip, the name and amount paid to each, and for what period paid.

Disbursing officers must be careful not to make payments in advance.

New contracts (in quadruplicate) will be made with each nurse when for any reason the rate of pay is changed, two copies to be forwarded to this office, with the oath, one copy to be given to the nurse, and one to be retained by the officer making the contract. The Christian names and surname of the nurses must be given in the contract, and her signature must correspond therewith. The new contracts will be exact copies of the old contracts, with the exception of the change in the rate of pay.

Transportation.—A nurse cannot leave her station except when ordered to do so, or when granted a leave of absence.

Before starting on a journey at public expense she must receive a written order from the proper authority, together with an order for her railway ticket and sleeper (or accommodations on a transport or other vessel). She must also have the date of her departure and the time to which she was last paid indorsed on her contract.

When travelling under orders no delay in starting and no stop-over privileges are allowed.

A nurse returning from service outside of the United States will usually be furnished transportation to New York or San Francisco. On arrival in either city she will proceed to the Army Building, where, on presentation of her travel order, she will be furnished transportation to her destination.

Transportation will not be furnished, nor will travelling expenses be allowed, for any journey which a nurse may take while on leave of absence, except that if she goes to and from the United States she may, if practicable, be authorized to travel on a Government transport.

Nurses, whether still in the service or not, will be reimbursed either by the Quartermaster's Department or by the auditor for the War Department for incidental expenses incurred in any journeys under orders. An itemized account, not to exceed $2 for each day of travel, must be prepared in duplicate and certified to before a notary. Blank No. 13, Quartermaster-General's Office, may be used for this. When possible, receipts for expenditures are to be appended, and the whole is to be forwarded to the Quartermaster-General, War Department, Washington, D. C., or to the nearest quartermaster, for settlement. In all cases the nurse must furnish her copy of the order in obedience to which she travelled, and if she was not given such copy (or has mislaid it), she must obtain it by application to the officer who directed her return home. This application may be enclosed in an envelope addressed to the surgeon-general of the army, who will forward it to the officer for compliance with her request.

Leave of Absence.—The total duration of leave of absence with pay granted a nurse shall not exceed thirty days in each calendar year, regardless of length of service.

The surgeon-general or chief surgeon of a military department or of an army corps, or the commanding officer of a general hospital, or surgeon in charge of a hospital, may grant leaves of absence to a nurse when it can be done without detriment to the service. No leave of absence will be granted unless requested by the nurse in writing. The nurse must furnish her copy of contract, on which the length of leave of absence, if granted, and whether with or without pay, will in all cases be indorsed. The officer will give to the nurse the paper granting the leave of absence, but will not furnish her orders on which she may secure transportation. The facts will be reported to the surgeon-general on information slip.

When a leave of absence is granted to a nurse on insular service, the time which may be spent in travelling to and from the United States will not be counted.

A nurse on leave of absence in the United States will report the fact, in writing, to the surgeon-general at least one week prior to the expiration of said leave.

At the close of her leave of absence a nurse must report in person at her station, if in the United States, otherwise to the Army Building at the port from which she is to embark for her station.

Special leaves of absence without pay may be granted under exceptional conditions, but shall not exceed thirty days at any one time, unless by authority of the surgeon-general. At places where the services of trained nurses are not otherwise obtainable a nurse may, if she so desires, and with the approval of the medical officer in charge of the hospital, be granted leave of absence without pay in order to take a private case.

An extension of leave of absence may be granted by the same officer and under the same conditions as the original leave of absence, or it may be extended by the surgeon-general.

Illness.—A nurse is entitled to receive medical attendance and medicines when ill. So far as possible this will be provided for at each hospital where she may be serving, but when it is reported as desirable the surgeon-general (or chief surgeon within his department) may give orders for a nurse's transfer to and treatment in some other army hospital. Bills contracted by a nurse for medical attendance cannot be allowed, nor will extra leave of absence with pay be granted because of illness.

The contract of a nurse who becomes ill while in the service will not be annulled during such illness, unless at her own request, but if she so desires she may be ordered to her home to await annulment of contract.

Transfers.—When the necessities of the service require it, nurses will be transferred from one hospital to another. A nurse ordered to duty outside of the United States will usually be expected to remain at least a year. Orders for transfers will be issued by the surgeon-general, except that where a chief surgeon has jurisdiction over more than one hospital he may order transfers between them, reporting the fact immediately to the surgeon-general.

Quarters.—Nurses will be furnished rooms or tents for sleeping, according to the accommodations available at each hospital, and where there are several nurses, one room or tent will be provided as a common sitting-room.

Sheets, towels, pillow-cases, table linen, and other washable articles furnished by the hospital for the nurses' use will be washed as part of the hospital laundry.

Rations.—A nurse is entitled to one ration in kind or commutation therefor, as stipulated in the contract.

Nurses will be served in a separate dining-room, if possible, and if their number warrants it; otherwise at different hours from men using the same room. They are entitled to the use of table linen which is supplied to hospitals.

A nurse while on leave of absence will be allowed commutation of rations at the rate of twenty-five cents a day. To obtain this she must apply to the Commissary General of Subsistence, U. S. Army, War Department, Washington, D. C., or to any commissary officer. In any case she must furnish her official leave of absence, which is to be retained by the officer making the payment.

Reports and Returns.—If the nurses assigned to any hospital are too few or too many, the medical officer in charge thereof will report that fact to the surgeon-general.

Every change in the status of nurses, such as arrival,

departure, leaves of absence granted, orders given, death, etc., will, on the day of its occurrence, be reported to the surgeon general by the medical officer in charge of a hospital. Information slips will be used for this purpose, giving Christian names and surname in each instance.

On the last day of each month the medical officer in charge will forward a return of female nurses under contract to the surgeon-general, through the chief surgeon, on blank form furnished by this office

He will forward directly to the surgeon general the efficiency reports prepared by the chief nurse, and will indorse thereon his remarks stating whether or not he concurs in the grading reported by her He will also indorse on it his report of the efficiency of the chief nurse, specifying in detail the character of the services rendered by her.

Uniform.—The uniform of the army nurse corps (female) consists of a white linen shirt waist and apron, with skirt, necktie, and, if needed, a short jacket of army blue galatea. A nurse provides for the laundry of her uniforms. A chief nurse shall wear a red silk sash knotted around the waist, with or without the apron

The badge of the corps is the cross of the medical department in red enamel, with gilt edge. This is pinned on the left side of the collar of the uniform or on a corresponding part of her dress when she is not in uniform.

When a nurse is appointed she will be supplied with detailed instructions on this subject, and will immediately procure her uniform. It will invariably be worn during her hours of duty.

Exceptions to the rules regarding uniform may be made by the surgeon general when deemed desirable.

Duties of a Nurse.—A nurse will study and conform to the rules of military discipline and obey strictly and without delay any order which may be given her by her superior officers or her chief nurse. A nurse will familiarize herself with the details of this circular, of which she will retain a copy, and will study such portions of the "Army Regulations" and "Manual for the Medical Department" (which are in the custody of the chief nurse) as relate to the performance of her duties.

When required by the climate the chief nurse may, with the approval of the medical officer in charge, substitute the eight-hour day for the usual ten or twelve hours of ward duty.

If a hospital is large enough to require it, one or more nurses may be assigned to duty as assistants to the chief nurse, and if several nurses are on night duty, one will act as chief night nurse.

A nurse will not receive presents from patients or from the relatives or friends of patients.

A nurse must carefully preserve her copy of contract and present it to the proper officer for indorsement whenever she is paid, or given orders, or granted leave of absence, or her contract is annulled

Dietist.—When assigned to duty as a dietist, a nurse will have the supervision, under the direction of the medical officer, of the preparation of food intended for patients unable to eat the usual ration She may also be required herself to prepare such food, or to instruct enlisted men in its preparation, or to attend to the drawing of rations or preparation of food for the nurses, or to perform such duties as may be assigned to her by the chief nurse, with the approval of the medical officer in charge; the whole to be regulated by the size and requirements of each hospital.

Chief Nurse.—The surgeon-general will appoint as many chief nurses as may be necessary, by promotion from the grade of nurse; such appointees to be reduced if unsatisfactory or if a less number of chief nurses are required.

If at any hospital one (or more) of the nurses proves herself possessed of marked executive ability, good judgment, and tact, she should be recommended for promotion by the chief nurse and medical officer in charge.

When a vacancy occurs, an eligible nurse will be appointed chief nurse by the surgeon-general.

Duties.—The position of chief nurse is, so far as army conditions permit, equivalent to that of a superintendent of nurses in a civil hospital. It is her duty to supervise the ward work of the nurses and see that it is kept up to the highest standard, to regulate the nurses' hours and assign each to her specific duty She will attend to their comfort and welfare, and see that they receive proper attention when ill, and will be responsible for their dignified and discreet conduct. She may make such rules for them as are approved by the medical officer in charge, and will see that the provisions of this circular and the directions of the medical officer are faithfully carried out.

The chief nurse will render efficiency reports of the nurses serving under her on the last day of March, June, September, and December of each year. A similar report will be made when she is about to leave a hospital, and whenever she may consider it desirable or it may be ordered by the surgeon-general. Special efficiency reports of an individual nurse will be made whenever one is ordered away from the hospital, or one whenever the chief nurse deems it desirable. Blanks for efficiency reports will be furnished by the surgeon-general.

In smaller hospitals, according to the circumstances in each, the surgeon may assign her additional duty, either in the wards or in charge of the linen room, or as dietist.

She will familiarize herself with the "Army Regulations" and the "Manual for the Medical Department," so far as they affect her duties, and will keep copies of these books for consultation by the nurses.

All reports will be addressed to the surgeon general and forwarded through the medical officer in charge. Any communication requesting or involving the issuing of orders is official and will follow the same channel.

Reserve Nurses.—A certain number of nurses who have rendered at least four months' satisfactory service in the army will be appointed reserve nurses.

Each reserve nurse will sign an agreement to enter active service wherever required and to report by letter to the surgeon-general on the 1st of January and the 1st of July of each year, and at other times if required. Reserve nurses wear the badge of the army nurses, but are not paid except when on duty

When assigned to active duty, they will be subject to all established rules and regulations and will receive the pay and allowances of nurses on the active list. On returning to her home from active duty, a reserve nurse will be granted eight (8) days' leave of absence with pay, in addition to that to which she may otherwise be entitled.

A nurse will be dropped from the reserve list upon reaching the age of forty-five years, or if she ceases for five years to practise her profession, or if she becomes incapacitated from ill health, or for any other good and sufficient reason. But a nurse shall not be dropped from the reserve list without information being furnished her of the cause for such action and an opportunity being given her to reply to any charges which may have been made against her

The official section regarding reserve nurses is considered one of the most important in the circular. For practical purposes reserves may express their preference as to whether they desire early assignment to active duty or whether they wish to be called upon only in time of war or national emergency.

Practical experience during and since the Spanish war has demonstrated the necessity of having a competent chief nurse at each hospital, the existence of a head being as important among the nurses as it is in other parts of the military organization.

One of the most useful duties to which nurses have been assigned is that of instructing hospital corps men in practical nursing and in cooking. This is being done in some of the army hospitals, and notably also in the two schools for hospital corps men at Washington Barracks, Washington, D. C., and at Angel Island, California. Since the summer of 1899 a trained nurse has been on duty at each of these schools as instructor in the preparation of diet for the sick. Fifteen lessons are given, of an

hour each, and the whole work is adapted to army use, including not only the preparation of liquid and light diets from hospital stores, but the utilization of the ordinary and the travel rations for the sick. A pamphlet entitled "Emergency Diet for the Sick in the Military Service," containing recipes which are taught practically at these schools, has been published and issued to army hospitals.

In the spring of 1900 one of the chief nurses was for the first time assigned to temporary duty as inspector of nursing at certain hospitals where women are stationed. This plan will probably be adopted whenever need therefor arises.

The spring of 1900 finds a few nurses still on duty in Cuba and a few at post and general hospitals in the United States, the largest number being forty on duty at San Francisco. About one hundred and forty nurses are serving at the various hospitals in the Philippine Islands, on the hospital ship *Relief*, and on transports in the Pacific ocean. It has been found desirable, whenever patients are returned from the Philippines, to place at least two women nurses on the transport which carries them.

It is desirable to compare the above history of the army nurse corps during and since the Spanish-American war with conditions which prevail elsewhere. In Europe, as a general rule, a limited number of women nurses are employed in army hospitals in time of peace, and provision is made through religious and secular channels for a large increase in case of war. In England, the regular nurses and also the reserve nurses belonging to the "Army Nursing Service" are secular, but on the Continent the women so employed are members of the religious sisterhoods. In our country the Catholic orders have but a comparatively small surplus beyond their own needs. The Red Cross societies of foreign countries are great organizations under government control, through which all civil aid to the army must come; but we have nothing similar to them in the United States, nor are they indeed altogether compatible with the liberal instincts of our people.

In our civil war Miss Dorothea Lynde Dix held the position of superintendent of women nurses, although that appointment carried with it no definite official status and no salary. The profession of the trained nurse did not exist at that time, and nurses were selected by Miss Dix for army contracts largely on account of their matronly age and manners. A notable proportion of the nursing during the civil war was done by women who were never officially appointed or paid.

When the United States again finds itself on the eve of war it is most desirable that admission to army hospitals should be absolutely limited to graduate nurses holding official appointments. If at that time we should have reverted to conditions similar to those existing at the beginning of the Spanish-American war, it would be necessary promptly to appoint a woman as superintendent of the army nurse corps. It is eminently desirable that this appointee should hold a commission as an officer of the army, and in order to do this she would, under present laws, necessarily be a physician. Her principal assistant should be a trained nurse, who would remain in the surgeon-general's office and have charge of the details regarding the selection of nurses. The superintendent herself should have direction of the organization of the service, subject to instructions given her by the surgeon-general, and should have authority to travel as much as might be necessary to secure the establishment of the service on a thoroughly satisfactory foundation. It is, however, unquestionably better for the army to maintain in time of peace the nucleus of what it will need in time of war, and it is hoped that the existing army nurse corps, organized as above outlined, may serve as such a nucleus.

Anita Newcomb McGee.

ARMY TRANSPORT SERVICE.—"The Quartermaster's Department of the United States Army is charged with the duty of providing means of transportation of every character, either under contract or in kind, which may be needed in the movement of troops and material of war. It furnishes all public animals employed in the service of the army, the forage consumed by them, wagons and all necessary articles for their use except the equipment of cavalry and artillery. It furnishes clothing, camp and garrison equipage, barracks, storehouses, and other buildings, constructs and repairs roads, railways, and bridges; builds and charters ships, boats, docks, and wharves needed for military purposes, and attends to all matters connected with military operations which are not expressly assigned to some other bureau of the War Department. Subsistence, ordnance, signal, medical, and hospital stores are procured and issued by other bureaus of the War Department, but the Quartermaster's Department transports them to the place of issue and provides storage for their preservation until consumed. When troops are moved suitable transportation is provided by this department. On railways the accommodation afforded by tourists' sleeping cars (a seat by day and a berth by night for each soldier) is furnished whenever practicable. On transports cabin passage is furnished to officers and reasonable and proper accommodations for the troops, and when practicable a separate apartment for the sick." Provision is also made by Army Regulations for the transportation by land and sea of the authorized allowance of baggage of troops and for the animals employed in the public service. These regulations, general in their nature, established by order of the President through the Secretary of War, are in their details extended by the quartermaster-general acting under the authority of the Secretary.

The Army Transport Service under the foregoing Regulations existed only as a subdivision of the multifarious duties performed by officers of the Quartermaster's Department, having no special and separate organization. It now operates as a division of that department under special regulations, having assigned to it officers and men of other branches of the service associated with civilian employees of various grades. It is an outgrowth of the Spanish war, and is yet in some of its features and details in process of development for adaptation to the war now in progress in the Philippines.

At the outbreak of the war with Spain the only transports available for moving troops oversea were ships of the merchant marine (save an occasional loan by the navy) hastily and temporarily refitted for the accommodation of soldiers and such of the converted navy cruisers as might be spared by the navy for their service. During the progress of the war, and especially in view of extensive and protracted military operations in the Philippines, it became apparent that for long voyages a special organization and equipment was requisite to insure the health and consequent efficiency of the troops on arrival in oversea ports in tropical waters. A board of officers was accordingly convened by the War Department in the month of September, 1898, for the purpose of formulating Regulations for this service. The board submitted its report, which received the approval of the Secretary and was published in the month of November following. Operations under the new Regulations began without delay. A number of steel steamships formerly chartered became the property of the Government. The work of refitting for oversea troop ships those of the fleet having the greater power and tonnage began in several shipyards on plans prepared or accepted by the department. The smaller vessels acquired and intended for the West India and coastwise service also received additions and alterations on less extensive plans adapted to the shorter voyages.

The new regulations established two home ports or headquarters for the Army Transport Service: one at New York for the Atlantic traffic, and one in San Francisco for the Pacific traffic. Each home port is to have its equipment of officers and employees and to be provided with proper terminal facilities. The general organization of both divisions is as follows, the personnel being duplicated in the two home ports:

1. General superintendent.
2. Assistant to general superintendent
3. Subsistence superintendent.
4. Medical superintendent.
5. Transport quartermasters and commissaries.
6. Transport surgeons.
7. Marine superintendent.
8. Assistant marine superintendent.
9. Superintending engineer.
10. Assistant superintending engineer.
11. Port steward.
12. Quartermaster's purveyor.
13. Chief stevedore.
14. Army transport agent at oversea ports.

The duties of these officers are in general indicated by their titles. The general superintendent, required to be an officer of the Quartermaster's Department, is charged with the general administration of the transport service. The assistant superintendent, required to be an officer of the Quartermaster's Department, performs the duties assigned him by the general superintendent and acts as his deputy during his absence. The duties of the medical superintendent are prescribed as follows: "To be an officer of the medical department of the army stationed with the general superintendent and acting as his assistant and professional adviser in all matters pertaining to the hygiene and sanitation of the transports and to the medical and hospital accommodations and service on board. He will make personal and minute inspection of each transport on arrival and prior to departure, and will submit to the general superintendent such recommendations relative to sanitation and hospital equipment as he may deem needful. He will make himself familiar with all the quarantine laws and facilities that may exist at home and in foreign ports, and be responsible for the competency and satisfactory service of the transport surgeons and all other employees of the medical department of the transport service. He will detain and make proper disposition of persons embarking or disembarking having infectious diseases, and will provide for the reception and care of disabled military passengers, and make to the subsistence superintendent such recommendations relative to the food supply as he may deem advisable."

"To each transport is assigned a transport surgeon who is selected or appointed with special reference to the needs of the transport service, and under the direction of the medical superintendent, and the transport quartermaster acts as the medical officer of the ship. He is responsible for the proper hospital equipment and (medical) supplies of the vessel, for its proper and thorough sanitation, for the care and treatment of the sick and injured, and for the satisfactory service of the hospital employees" The transport surgeon is also charged with the direction of fumigating the ship when such action becomes necessary by the presence of infectious diseases on board. When inspection of the troops on board under arms is ordered, the surgeon attends such inspection and examines the condition of the men to ascertain whether they exhibit signs of disease. He is required to make a daily inspection of berth and lower decks, lavatories, bathrooms, galleys, and the hospital, in company with other designated officers In addition to other duties prescribed for him by the transport service Regulations the transport surgeon, acting as a medical officer of the army, is guided in general by Army Regulations and by such special instructions as he may from time to time receive from the medical superintendent. The transport surgeon is subordinate to the transport quartermaster, who has general charge of the ship and supervision of the conduct and efficiency of the ship's officers and employees of all grades and in all departments. The duties of transport commissary are ordinarily performed by the quartermaster, but an officer of the subsistence department may be assigned to both functions.

The ship's company is divided into four departments, viz.: the deck department, the engine department, the steward's department, and the hospital department; their functions being specifically set forth in the Regulations. The master has full control of the navigation of the ship and is responsible for the discipline and efficiency of the crew. The Regulations provide rules for the embarkation of troops, the stowage of baggage, and for the routine on board; for convoys, for the official relation between the commander of the troops and the ship's officers, and for the disembarkation of troops. Especial provision is made for the care of the water supply, the messing of the troops, protection against fire at sea, and the maintenance of cleanliness on board.

Apart from the general duties prescribed in the original Regulations for transport surgeons it is to be noted that the organization and equipment of the medical service of the transports is omitted. No hospital facilities, save makeshifts, existed on any of the chartered transports in the Atlantic division. In the plans for refitting vessels for troop ships prepared by the superintending engineer, special provision is now made for hospitals in all ships designed for oversea service, which include the fixtures and apparatus of a complete hospital outfit sufficient for the needs of a regiment in transit and of those of the ship's company requiring hospital service during a voyage possibly protracted beyond a period of two months. On an estimated sick list of five per cent. of hospital cases of all on board not provided with cabin accommodation, hospital accommodations of seventy-five beds (not including field cots for emergencies) have been installed on the larger and later troop ships despatched from the port of New York to Manila.

The amended Regulations provide as follows·

Medical Department.—The hospital is under the charge of the transport surgeon, who is responsible for the proper care and use of the hospital property and equipment and for the discipline and instruction of the hospital attendants. The hospital will not be used for other purposes than for the accommodation of the sick, without the approval of the transport surgeon.

The personnel of the medical service on army transports will be detailed from the medical service of the army, by proper authority, on the recommendation of the medical superintendent. Transport surgeons will keep a record of sanitary inspections and during each voyage will note: 1. The quality and quantity of the water supply of the vessel. 2. The quantity, quality, and cooking of the rations. 3. The ventilation of all berth decks, including staterooms and the hospital. 4. The adequacy and cleanliness of the bedding and clothing. 5. The sanitary condition of bathrooms, lavatories, closets, and storerooms. 6. The prevalence (or absence) of infectious diseases on board.

During the voyage the transport surgeon will make to the transport quartermaster such recommendations for the correction of defective sanitation on board as may be noted during inspections. On completion of the voyage he will submit a sanitary report (Form 41, Medical Department) of the vessel with copies of special reports made during the voyage and the action of the transport quartermaster thereon.

The transport surgeon will make a physical examination of men applying for shipment with the crews of army transports, reporting to the transport quartermaster on their physical fitness for service and transmitting to the medical superintendent (Form 31, Medical Department) a record of such examinations.

No intoxicating liquors of any kind will be brought, or secretly used on board by any employee, and no issues of any intoxicating liquor will be made to employees except on the recommendation of the transport surgeon approved by the transport quartermaster.

The sick in hospital will be supplied with such articles of diet as may be prescribed by the transport surgeon under G. O. 37, A. G. O., 1899,* and when there is no special diet kitchen aboard ship these articles will be furnished from one of the established messes. The trans-

* This order establishes a credit of forty cents per diem, in lieu of the ration, with the transport commissary for each soldier reported sick in hospital.

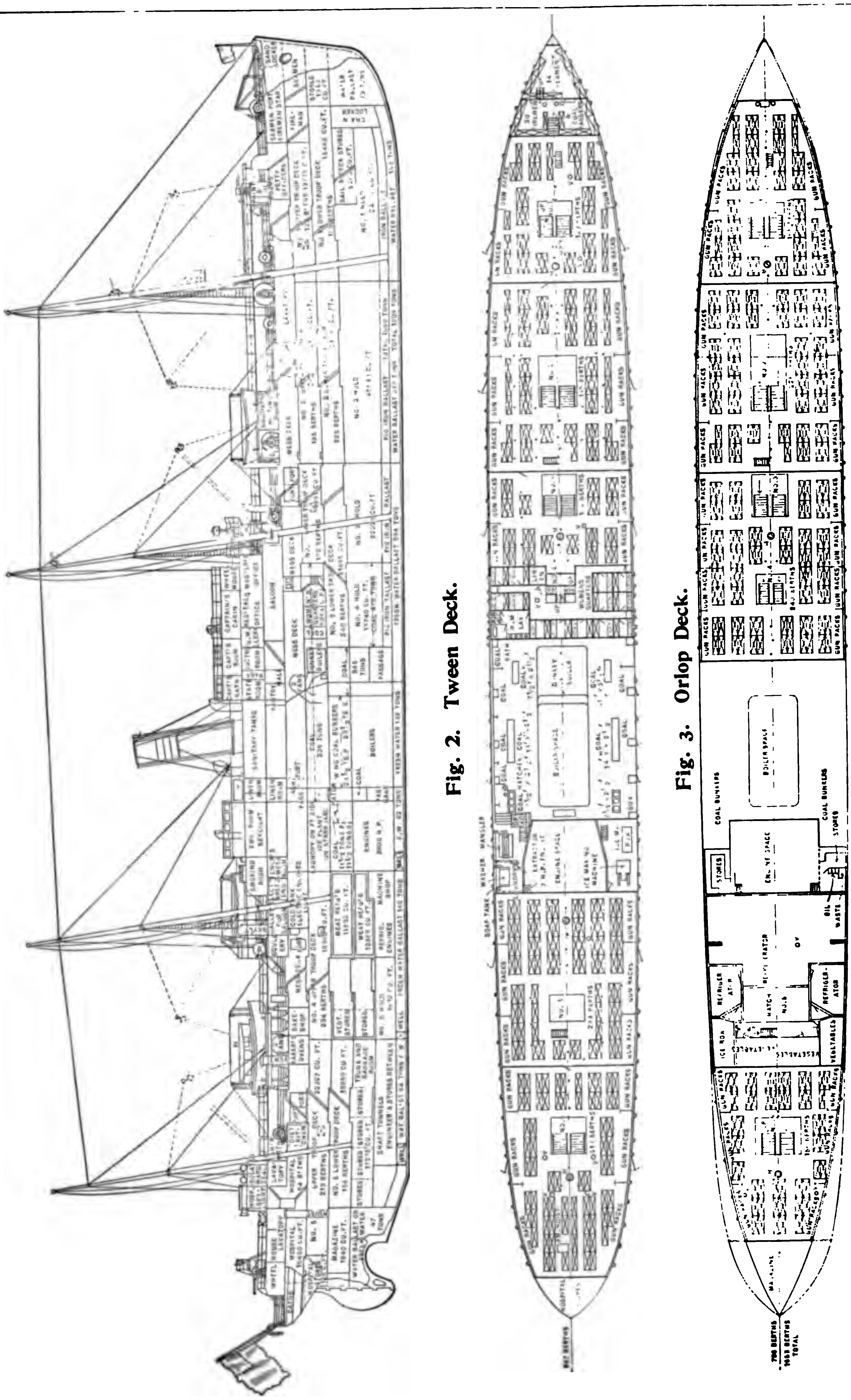

Fig. 1. Mid-Ship Section.

Fig. 2. Tween Deck.

Fig. 3. Orlop Deck.

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port commissary will designate the mess from which these articles will be supplied

The location assigned to the hospital on all troop ships, save one, is the after part of the main deck (mess deck) for the main ward, an isolation ward being built over this and communicating by an inside hatchway with it. The deck plan (main deck) is shown in Plate IX., Fig. 9, hereto attached. In the forward part of the hospital there are partitioned off the main ward, an office, dispensary, operating room, linen room, special diet kitchen, and two attendants' rooms. On the sides, fore and aft, are lockers for patients' clothing. The after part is partitioned for baths, closets, urinals, and laundry tubs. A storeroom for medical supplies is placed aft and below with a hatchway in the ward through the main deck. Above, on the promenade deck, is an isolation ward of twelve beds, two being enclosed for the treatment of refractory patients. This ward is provided with a separate bath, lavatory, and closets, and is accessible from below as well as from the deck. The deck floor of the main ward is laid over with cement on which is fixed a layer of linoleum. The deck floors of the kitchen, baths, dispensary, and operating rooms are tiled. The berth sections are double tiered, steel frames having wire mattresses and side slats, and are secured to the deck. Ventilation is effected, first, by overhead air ducts leading from the fan ventilating service of the ship; second, by open ports through the sides; third, by small movable electric fans within the ward. Heating is effected by the passage of warmed air through the ventilating conduit heated by steam coils and propelled by the steam fans. The air supplied by the conduits is also cooled by passing over refrigerating coils instead of steam coils and delivered in the same manner as the warmed air. By this device warmed air, cooled air, and air at outside temperatures may in turn be distributed by the fans. The dimensions of the main ward are, rooms included: length fore and aft between bulkheads, 44 feet; breadth at forward bulkhead, 39 feet; at after bulkhead, 32 feet; height between decks, 7 feet—indicating a total capacity of 16,400 cubic feet, or 644 cubic feet per berth section, fixtures included.

The diet kitchen is fitted with steam cooking fixtures and racks for utensils and mess furniture. The dispensary is fitted with shelves, drawers, bottle racks, etc. The operating room is provided with an outfit of instruments and apparatus for surgical operations, an electric heater for a sterilizer, and a portable electric light. The wards and rooms are lighted by incandescent lamps. All the plumbing is open sanitary work. The personnel of the hospital service consists of one surgeon, one acting hospital steward, and three privates of the hospital corps; these to be assisted by details of hospital corps, privates from troops in transit. The sick in quarters among the troops are attended by the medical officers accompanying them. Medical supplies for two thousand men for a period of six months are placed on board the oversea transports in the port of New York. These include bedding, hospital clothing, medicines, hospital stores, surgical instruments and dressings, disinfectants, etc.

On the coastwise transports the same general plan is adhered to, but the hospitals have less capacity and the fixtures and equipment are correspondingly less complete. These ships also have facilities for the isolation of infectious diseases, and their hospital outfit includes medical supplies for a period of three months for the maximum carrying capacity for troops and crew. Medical supplies of transports are replenished from depots in New York and San Francisco, and, in cases of emergency, at oversea ports where temporary depots have been established. The general arrangement of the oversea transports for the accommodation of the troops is shown in Plate VIII., Fig. 1, which is a sectional view of the troop ship *Thomas* refitted at Cramp's shipyard, Philadelphia, and cleared from the port of New York for Manila, P. I., November 4, 1899, carrying a regiment of United States Volunteer Infantry, a detachment of the army hospital corps, female nurses and other military passengers, besides a variety of military stores, freight, and baggage The dimensions of this transport are, length 445 feet, beam 50 feet. Capacity, tons gross, 5,713. Berthing capacity for troops, 1,653. Total berthing capacity, 2,156. On the main deck (see Plate IX., Fig. 9) forward are berths for petty officers and seamen. Abaft of these quarters is a soldiers' lavatory containing sixty-four basins with hot- and cold-water taps, a number of closets, urinals, and shower baths over a cemented deck floor. Amidships on this deck the space not occupied by hatches and machinery is allotted to the messing arrangements of the troops and crew. A steam galley provides coffee, soup, and meat, six hundred rations of each at one time for the troops. An oven of sufficient capacity furnishes fresh bread for all on board. A large coffee mill is operated by electricity. A scullery, butcher shop, cold-storage room, and separate mess room for non-commissioned officers, firemen, oilers, and seamen find places on this deck on both port and starboard sides of the engines. The remaining deck space, from the engines forward to the lavatory, is fitted with folding mess tables and benches which when not in use are stowed between deck beams overhead. The troops are berthed below in nine compartments on the 'tween and orlop decks. The berth sections, having three tiers of berths each, are built of galvanized steel pipe fitted with canvas bed bottoms lashed by their margin to the piping and changeable for washings. The arrangement of the sections on the two berth decks is shown in Plate VIII., Figs. 2 and 3. A part of the crew berth in the forward part of the 'tween deck. Air ducts leading from the ventilating fans open into all berth compartments. The air space on troop decks per berth varies from eighty to one hundred and twelve cubic feet, fixtures included. Gun racks are fitted to the ship's sides in these compartments. Easy access to the berth decks is afforded by double stairways through large hatches, one or more in each compartment. On the 'tween deck forward of the engine space are separate staterooms, a closet and lavatory for women. A steam laundry with ironing and drying apparatus is installed on the port side, and an ice machine on the starboard side of the engines on this deck. On the orlop deck amidship are cold-storage rooms for meat and vegetables. The compartments below the orlop deck are allotted to storage and freight. Above on the spar deck staterooms for officers occupy both sides amidship, having aloft the engines, bathrooms, and closets. Forward of the engines on the spar deck is a dining saloon seating eighty persons, with a steam galley, ice-box, cold-storage room, and distilling apparatus adjoining the engine room, as shown in the spar-deck plan (Plate IX., Fig. 8). On the after part of this deck is another soldiers' lavatory, with baths, closets, and urinals accessible from the main and berth decks through the after hatchway. Between the second and third forward hatches on this deck is a soldiers' writing room. On the promenade deck amidship are additional staterooms and office rooms for officers and a smoking room (Plate IX., Fig. 7). Aft on this deck is built an isolation ward (Plate IX., Fig. 5), capacity twelve berths, communicating with this deck and with the main ward below. The upper (bridge) deck has rooms for the master and chief officers of the ship (Plate IX., Fig. 6).

The ventilating system is worked by two sets of fans, one forward, another aft, on the spar deck, with metal air ducts leading to all berth-deck compartments and to some storerooms. The fans work either by incast or exhaust, as required, and deliver air at outside temperatures, or warmed, cooled, or filtered according to the situation and needs of the ship. The rated capacity of each of the four fans with 500 revolutions per minute is 25,000 cubic feet of air per minute. At a trial test of the apparatus made by the builders the velocity of the air current passing into the air cleansing and cooling device attached to the fan was ascertained to be 1,000 feet per minute, with a discharge velocity in the hospital of 940 feet per minute and in the lower troop deck (at the farthest point from the fan) 950 feet per minute. Tests made in reduction of temperature (at a lower rate of speed of the fan of the

air by the refrigerating device, the temperature on deck being 80° F. and that of the water used 60°, showed a reduction of temperature of the air delivered to 62° F. This system may be regarded as on trial, as no complete reports of its performance under varying conditions at sea are yet available. Twelve hundred tons of fresh water may be shipped as ballast. Fresh-water tanks furnished with refrigerating coils are placed on the mess deck where they are accessible to the troops. The equipment of the ship includes fire plugs and hose and the customary marine life-saving apparatus. The commissary department is provided with a variety of subsistence stores, including the components of the ration and additional articles for sale to the troops and for issue to the sick, with fresh beef and vegetables in cold storage. Facilities for military exercises are afforded on the main deck by stowing the mess-room furniture. A library of miscellaneous books has been contributed to the hospitals of each one of the troop ships by the Red Cross organization through their New York agent.

A distinctive uniform is authorized for the employees of the transport service, and the ships fly the colors of the department. In general the object kept in view by officers of the army transport service has been to maintain the efficiency of the troops while on board by all practicable military methods, in order that on debarkation after a voyage they may be fit for active service without delay for recuperation. That this end has been attained in great measure is evident from reports of voyages made to distant oversea ports by troop ships refitted and despatched under the direction of the transport service. Recent experience has emphasized the fact that in modern warfare the most difficult problems are those involving celerity of movement of troops and the *matériel* of war without the precipitancy and disorder which invite loss and disaster. The development of land transportation by the American people has already reached an extent and efficiency which place them in the lead among nationalities. If this ascendancy is to be maintained a similar development appears requisite on the high seas. The work of the army transport service is a beginning in this direction. At the present writing a board of officers has completed its sessions for the purpose of revising the original Regulations of the transport service in order to adapt them to its requirements as determined by the condition of its operation from its organization to the present time.

Henry S. Kilbourne.

ARNICA.—*Leopard's Bane; Mountain Tobacco. Arnica* L. is a genus of the *Compositæ*, containing some eighteen species distributed through the cooler regions of the north temperate zone, of which *A. montana* L. has been extensively employed in medicine. It is a native of eastern and middle Europe, and yields two official articles, as follows: *Arnicæ Flores*, "the flower heads," and *Arnicæ Radix*, "the rhizome and roots."

FIG. 284.—Arnica: flowering head. (Baillon.)

The plant is rather pretty, with a radical rosette of obovate leaves, from which rises a simple stem a foot or two high, bearing one or two pairs of leaves and terminated by from one to several large yellow flower heads.

Arnicæ Radix is thus described in the Pharmacopœia: "Rhizome about 5 cm. long and 3 or 4 mm. thick; externally brown, rough from leaf scars; internally whitish, with a rather thick bark, containing a circle of resin cells, surrounding the short, yellowish wood wedges, and large, spongy pith. The roots are numerous, thin, fragile, grayish brown, with a thick bark containing a circle of resin cells. Odor somewhat aromatic; taste pungently aromatic and bitter."

FIG. 285.—Involucre and Receptacle of Same. (Slightly enlarged.)

Arnicæ Flores are thus described: "Heads about 3 cm. broad, depressed-roundish, consisting of a scaly involucre in two rows, and a small, nearly flat, hairy receptacle, bearing about sixteen yellow, strap-shaped, ten-nerved ray florets, and numerous yellow, five toothed, tubular disc florets, having slender, spindle-shaped akenes, crowned by a hairy pappus. Odor feeble, aromatic; taste bitter and acrid."

The receptacle of this head is very apt to contain the larvæ of an insect, wherefore some pharmacopœias direct that the florets only shall be employed. Several other yellow flower heads have been employed to substitute or adulterate arnica, but all fail to combine the one to two serialled involucre with the pitted and hairy receptacle.

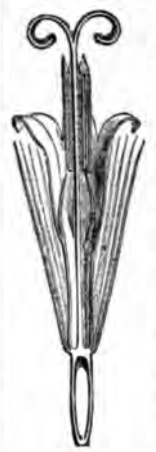

FIG. 286.—Single Flower of Same. (Enlarged.)

Both drugs have a strongly resinous odor and a pungent and acrid taste, that of the root being the stronger, and the dust of both is sternutatory. Their composition is similar, the rhizome being the stronger, with one-half to one per cent. of volatile oil, considerable resin, part of it acrid, ten per cent. of inulin, a little tannin, and the crystalline yellow acrid and bitter amaroid *Arnicin* ($C_{20}H_{30}O_4$), soluble in alcohol. The flowers lack the inulin, and their percentages of oil and resin are smaller. Their oil does not appear to be identical with that of the rhizome. Altogether, it would appear desirable to discontinue the use of the flowers.

Arnica is very active, both locally and systemically. It is a slow but powerful rubefacient to the external skin, and a powerful stimulant to raw surfaces, with some antiseptic power. It is highly irritating to mucous surfaces, being a stomachic and laxative in small doses, but an emetico-cathartic poison in overdoses. Besides its irritant poisonous properties, it is a systemic poison. Its systemic action is most concisely stated by Bartholow as follows: "In small medicinal doses arnica increases the action of the heart and arteries, and excites the functions of the skin and kidneys. In large doses, probably after a stage of excitement, depression of the circulation, of the respiration, and of the animal temperature ensues; violent headache is experienced, the pupils are dilated, and paresis of the muscular system comes on. In toxic doses, arnica paralyzes the nervous system of animal and organic life, and death ensues in a condition of collapse."

It would seem that some more important use might be found for a drug possessing such pronounced physiological actions as arnica than any yet developed. It has been used like aconite in reducing fever and decreasing the painful symptoms of many inflammations, especially in rheumatism, erysipelas, and painful menstruation. Externally it is a favorite vulnerary and rubefacient in

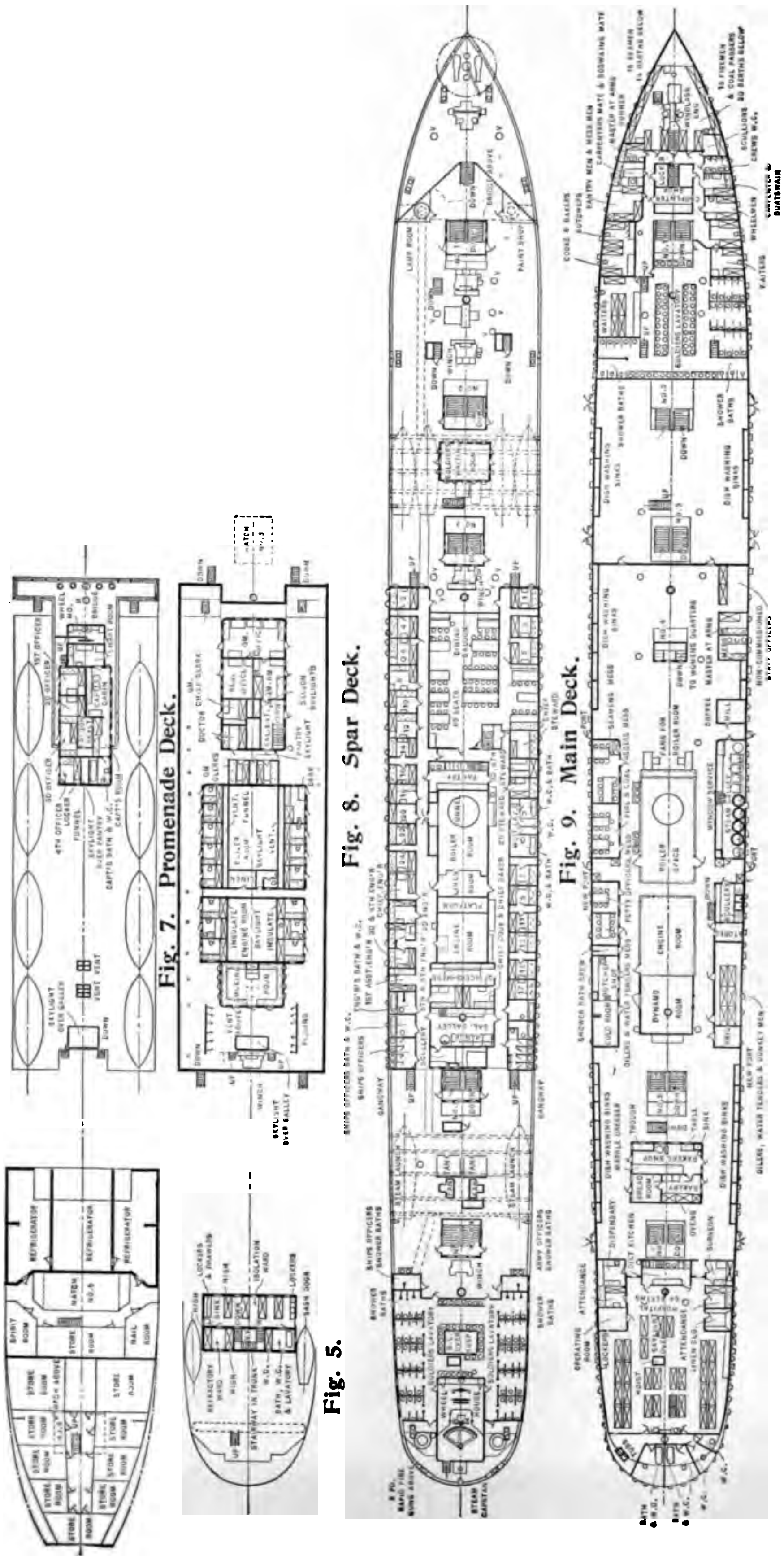

Fig. 4. Lower Deck (aft).

Fig. 5.

Fig. 6. Upper Deck.

Fig. 7. Promenade Deck.

Fig. 8. Spar Deck.

Fig. 9. Main Deck.

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domestic practice. We have a tincture of the flowers of twenty per cent., and one of the rhizomes of ten per cent. strength, the dose of each being 0.6 to 2 c.c. (♏ x. to xxx.); of the root a fluid extract, dose 0.3 to 0.6 c.c. (♏ v. to x.) and an extract, dose 0.06 to 0.2 gm. (gr. i. to iij.).

H. H. Rusby.

AROSA, Switzerland, is an Alpine high-altitude health resort of the Grisons in the southeastern portion of Switzerland. It is twenty miles from Coire, the railway terminus, and is reached by diligence in five and three-quarters hours. It is 5,900 feet above sea level, and lies in a sheltered position on the slopes of the Tschuggen, high above the Aroserwasser valley. From the fact that it is situated on the mountainside, Dr. Williams ("Aerotherapeutics") thinks that it, as well as St. Moritz and Wiesen, possesses an advantage over Davos, which is mainly situated in the valley.

Arosa has come into favor as a health resort, especially in the winter, for tuberculosis patients, only within the last eight or ten years. "Arosa, the latest on the list of Alpine climatic stations," says Dr. Ewart, "offers all the guarantees for becoming one of the first among the best. I am astonished that a region possessing such qualifications should have remained unappreciated so long."

It is surrounded on all sides by massive mountains which protect it from high winds with the exception of the *foehn*, which appears occasionally here as in all Alpine valleys. The village is picturesquely situated in the midst of large fir forests, and the habitations are arranged in groups, terraced upon the mountain slope and facing the south. The hotel accommodations are good, and some if not all of the hotels are now arranged for winter occupancy. Dr. Egger here made his famous experiments upon the changes in the blood caused by altitude, and thus attracted the attention of the Profession to Arosa.

This table adapted from Regnard's "La Cure d'Altitude" shows the mean temperatures for the period 1889–92:

	Mean.	Maximum.	Minimum.
January	40.2° F.	40.8° F.	– 2.7° F.
February	40.7	41.3	– 1.6
March	38.0	48.5	– 3.8
April	32.7	52.5	12.0
May	43.7	63.1	21.5
June	48.3	72.0	30.9
July	50.1	73.7	30.4
August	51.8	73.9	29.5
September	47.1	66.7	29.1
October	37.4	60.4	9.7
November	31.3	47.5	10.0
December	23.7	43.5	– 0.9

The mean temperatures of the winter (December, January, and February), and of the summer (June, July, and August) are as follows (Regnard):

	Mean.	Maximum.	Minimum.
Winter	23.0° F.	41.3° F.	– 1.8° F.
Summer	50.2	71.4	33.8

The mean temperature at Arosa is about three and a half degrees higher than that at Davos, although the latter station is nine hundred feet lower than the former.

FIG. 287.—Arosa, 5,900 Feet Above Sea Level.

The minimum winter temperature at the two places is as follows:

	Minimum.
Winter 1891–1892, Arosa	– 8.7° F.
Winter 1891–1892, Davos	– 12.6
Winter 1892–1893, Arosa	– 16.6
Winter 1892–1893, Davos	– 24.5

In comparison with Zürich, which represents the temperature of the lowlands of Switzerland, we have the following for summer and winter (Regnard):

	Winter.			Summer.		
	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.
Zürich, elevation 1,600 feet	26.6° F.	41.7° F.	11.48° F	60.8° F.	81.3° F.	46.7° F.
Arosa, elevation 6,100 feet	23.0	41.0	–1.2	48.4	71.8	32.7

Violent variations of temperature are said to be rare at Arosa, and the fogs which are frequent in summer are very uncommon in winter.

The relative humidity for the winter of 1890 was as follows: The mean in December was 59 per cent., in January 62, in February 59, in March 65.

The greatest amount of precipitation occurs in summer in the form of rain; in winter it comes as snow, in sudden squalls which are soon over. In 1890 there were 1,886.4 hours of insolation at Arosa; and for the months of December and January, 492 hours of sun in compari-

son with 197 at Zurich at the same season, and 457.4 at Davos—an average of about five and a half hours a day.

The winter climate of Arosa, as we learn from the above, is characterized by a dry, cold, pure atmosphere, a high average of sunshine, absence of winds and fog, and the attenuation and clearness of the air which are the accompaniments of high altitudes. None of the Alpine health resorts would seem to offer more favorable climatic conditions for the high-altitude treatment of phthisis.

A discussion of the class of cases suitable for such a climate will be given under *Tuberculosis, Pulmonary*, but in brief it may be said that incipient cases with little constitutional disturbance have a better chance of recovery in high altitudes than elsewhere. The writer would express his indebtednees for much of the above data to Regnard's "La Cure d'Altitude."

Edward O. Otis.

ARRINGTON MINERAL SPRINGS.—Atchison County, Kansas.

POST-OFFICE.—Arrington.

ACCESS.—Via Union Pacific Railroad. Hotel.

These springs are located on a tract of land eighteen acres in extent, in a level, highly fertile farming country. The springs are three in number, and flow about eight gallons per minute. The following analyses of two of the springs were made by Juan H. Wright, M.D., chemist, of St. Louis, Mo.:

SPRING NO. 1 (REACTION DECIDEDLY ALKALINE).

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	9.76
Magnesium carbonate	5.93
Sodium carbonate	11.45
Potassium carbonate	1.44
Iron carbonate	3.57
Lithium carbonate	0.47
Sodium carbonate	2.04
Calcium sulphate	1.29
Magnesium sulphate	1.87
Sodium chloride	3.63
Silica	0.97
Ammonium crenate	0.89
Organic matter	0.27
Total	43.58
Carbonic acid gas	42 cubic inches.

SPRING NO. 2 (REACTION ALKALINE).

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	6.61
Magnesium carbonate	3.26
Sodium carbonate	3.55
Iron carbonate	2.01
Sodium chloride	2.16
Silica (soluble)	0.55
Organic matter	0.91
Ammonia	Trace.
Total	19.05
Carbonic acid gas	39.30 cubic inches.

These waters are both of the alkaline-chalybeate-carbonated variety. They are highly esteemed in dyspepsia, general debility, rheumatism, constipation, hemorrhoids, and liver and kidney complaints. Commodious bathrooms, supplying hot and cold water, are open to visitors.

James K. Crook.

ARROW-HEAD HOT SPRINGS.—San Bernardino County, California.

POST-OFFICE.—Arrow-Head Springs.

ACCESS.—By stage from San Bernardino, six and a half miles distant to the south. Parties leaving Los Angeles, sixty-seven miles distant, should take the 8:30 or 11 A.M., or the 12:20 P.M. Santa Fé train, or the 7:45 or 8:30 A.M. train on the Southern Pacific line. Hotel.

These springs burst from the mountain slope of the Sierra Madre, 2,000 feet above the level of the sea, and 1,000 feet above the foot of the mountain. A bench-like mesa, containing 100 acres, projects at this point from the mountain, and is bounded on the east and on the west by two enormous cañons. Down the deep ravine or cañon on the east comes a mountain stream of water as cold as ice, while in the cañon on the west flows a stream formed by the boiling spring so hot that it fills the air with steam and sulphurous gas. The springs here were known to the Indians long before the settlement of the country by whites. On the face of the mountain back of the hotel is the figure of an arrow-head 1,360 feet long and 450 feet wide, believed to have been executed by the aborigines. The figure gives its name to the resort, and so perfect is its contour and so elevated its situation that it can be seen from almost every part of the valley, and stands as a prominent landmark for miles around. The Arrow-Head Hotel is located near the springs, on the plateau of land between the two cañons. It is a very comfortable modern structure with a capacity for 150 guests. The meteorological conditions are similar to those usually prevalent in Southern California, the weather being, as a rule, clear, balmy, and bright. The winter season is most favorable for visiting the springs. These are 37 in number, the aggregate flow of water being equal to 10 miner's inches. Following is an analysis of one of the fountains by Prof. E. W. Hilgard, of the State University:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Potassium sulphate	4.00
Sodium sulphate	42.48
Sodium chloride	8.18
Lithium	Strong test.
Calcium sulphate	1.34
Calcium carbonate	1.34
Barium	Faint test.
Strontium	Well marked.
Magnesium sulphate	0.15
Magnesium carbonate	0.32
Silica	4.94
Organic matter	Trace.
Total	62.75
Free sulphureted hydrogen	0.264 cubic inches.

The water shows a very high temperature, 193° F. The analysis bears some resemblance to that of the Carlsbad springs. The water is soft, clear, and pleasant to drink and is believed to aid in the elimination of malarial and miasmatic poisons from the system when taken internally. The springs owe their chief reputation, however, to the beneficial effects of the water when used for bathing purposes. It is employed in the form of vapor, hot mineral water, and mud baths. These baths have proved of value in cases of glandular enlargements, rheumatism, and rheumatoid arthritis, as well as in some of the manifestations of syphilis and in various neuralgic conditions.

James K. Crook.

ARROWROOT.—*Arrowroot Starch; Maranta Starch.* The starch obtained from *Maranta arundinacea* L. (fam. *Marantaceæ*). The genus *Maranta* contains some fifteen species, natives of tropical America. They are perennial herbs, with tuberous or thickened, starch-laden, scaly rhizomes, and leafy, often branched stems.

The arrowroot plant is extensively cultivated in nearly all tropical countries. A large amount of arrowroot is now produced in Southern Asia. The Indian plant differs somewhat from the American, but is considered as only a variety of it.

The early medicinal application of arrowroot among the aborigines appears to have been as a remedy for the wounds of their arrows, to which it owes its name. It was both given internally and applied as a poultice to the injured part. It was also used as a food. Accounts of its cultivation in the West Indies date back about a hundred and fifty years, since which time it has been an article of general commerce.

Arrowroot is prepared in essentially the same way as other starches, namely, by washing it out of the cellular tissue. The yield is about ten per cent. of the fresh rhizome. That of the West Indies, generally called

Bermuda arrowroot, is regarded as the best. It is a beautifully white, lumpy powder, without odor or taste; rubbed between the fingers it gives a slight crackling sound, or rather, feeling, for the sensation is conveyed more through the fingers than the ears. Its other properties are simply those of starch in general, to which the reader is referred.

When the antiphlogistic treatment of diseases was more in vogue than at present, arrowroot took quite an important place in the dietary of the sick. It was also extensively used as an ingredient of foods for infants. For neither of these purposes is it to be much recommended. As a food, it has scarcely any advantages over the cheaper indigenous starches now so admirably prepared.

Florida Arrowroot is a starch prepared from the large fleshy stem of *Zamia integrifolia* Jacq. *W. P. Bolles.*

ARROWROOT, INDIAN. See *Curcuma.*

ARSENIC.—1. General Medicinal Properties of the Compounds of Arsenic.—The predominant feature of the action of arsenical preparations is intense irritation. Locally applied in fairly concentrated form to a denuded surface the irritation is so severe as to excite the extreme of reaction, namely, gangrenous inflammation; the part sloughs, strangulated by congestion and inflammation. Arsenic is thus indirectly, and, because indirectly, is slowly, painfully, and dangerously caustic. When arsenic is used to cauterize, there is also a risk of absorption of enough of the mineral to produce constitutional poisoning, a risk greater when the application is weak than when it is strong, since in the latter case congestion is developed early, whereby absorption is impeded. When arsenic is taken internally, gastro-intestinal irritation is easily produced, a result which, in acute arsenical poisoning, constitutes the most prominent feature of the derangement. Apart from tendency to irritate, arsenic is fairly antiseptic, and in the higher organisms, such as man, has an action upon the nervous system. In arsenical poisoning nervous symptoms are prominent, and, therapeutically, much of the avail of arsenicals hinges upon the allaying of nervous derangements.

For the purposes for which arsenic is used in medicine, the remedy has to be administered continuously for days, weeks, or months. In this medication the rule is so to adjust the dosage as not to develop constitutional disturbance. The initial symptoms of over impregnation of the system with arsenic are, first, an irritation of the conjunctiva, showing itself in suffusion and smarting of the eye, and œdema of the lower lid; and secondly, an irritation of the stomach, shown by failure of appetite and soreness and sensation of weight at the epigastrium. In some persons the gastric symptoms precede the conjunctival. The two sets of symptoms should be watched for in arsenical medication, and the dosing diminished or temporarily discontinued until their abatement, which speedily follows the withdrawal of the poison.

The properties of arsenic valuable therapeutically are as follows:

(*a*) *Improvement of Nutrition.*—Even in the healthy, carefully graduated dosage with arsenic tends to improve general nutrition, the individual fattening, the skin being specially rosy and smooth, or, in animals, the fur sleek and glossy, and the bones thick and dense.[1] In the case of the so-called arsenic-eaters of Styria, the women are said to indulge for the beautifying of their complexion, and the men for an improvement of wind and increased physical endurance which they claim to derive from the use of arsenic. This habit of regular consumption of arsenic among certain of the working class in Styria seems now established as a fact by competent and reliable testimony.[2] Arsenous acid is the preparation commonly used, and the daily allowance has been known to reach five and even ten grains. But attempts in other countries to acquire the tolerance of the poison which the Styrian peasantry show commonly end in disaster. The property of arsenic to modify nutrition is utilized principally in the following diseases: *Progressive Pernicious Anæmia:* In this affection, where iron is so notoriously futile, arsenic has in many cases proved of great benefit, patients even recovering fully under its use. *Scaly Skin Diseases:* In skin diseases arsenic is more or less used, but experience agrees that it is much more likely to be of benefit in affections of the epidermis than in those involving the corium. *Psoriasis* is a typical disease of the former kind, and in its treatment arsenic is a standard remedy. At the beginning of an arsenical course the symptoms often suffer an exacerbation, but this commonly subsides in a few days. The medicine should not be prescribed during the inflammatory stage of a skin disease, but when used should be persisted in for weeks, or even months, after apparent cure. Under all circumstances the remedial action is slow.

(*b*) *Control of Neuroses.*—The property of arsenic to affect nerve functions, seen in the nervous phenomena that attend arsenical poisoning, shows itself therapeutically in a tendency to abate pain, spasm, and undue reflex irritability. The property is utilized most especially in the following conditions: *Gastric Irritability:* In idiopathic dyspeptic irritability of the stomach, or in the irritability attending the chronic gastritis of drunkards, or ulcer or cancer of the stomach, arsenic is often of considerable benefit, and is especially efficacious when the nervous disturbance is disproportionately great. *Neuroses of the Respiratory Organs:* Some asthmatics find a certain amount of temporary relief from arsenic, a relief more likely to be obtained in the pure neurotic form of the disease than when the symptoms are secondary to bronchitis, emphysema, or disease of the heart. Yet also the nerve irritation in coryza may be relieved, and, according to Ringer, paroxysmal sneezing is often promptly broken by the remedy, except when caused by true hay fever the result of the inhalation of pollen. *Other Neuroses:* In *chorea* arsenic is probably the most generally serviceable of medicines. Simple uncomplicated cases recover under the use of the remedy more frequently than not. *Neuralgia* also sometimes yields to arsenic, more particularly when the attacks show a regular periodicity of onset; in other words, when the affection is very likely of malarial origin. Other neuroses also, such as angina pectoris, and even epilepsy, have occasionally been treated by arsenic, and isolated cases have been reported in which benefit has been claimed from the medication.

(*c*) *Control of Malarial Diseases.*—Arsenic has a notorious power over malarial affections, being commonly resorted to as next choice after the cinchona alkaloids. In a broad way arsenic is inferior in potency to those alkaloids, but yet in old cases, and particularly in intermittents of tertian and quartan rather than quotidian type, it may succeed even after quinine has failed. As compared with quinine, furthermore, arsenical preparations have the advantage of being tasteless and cheap, and for those reasons alone may be selected for prescription in malarial disease in the case of poor people or of children.

Besides the foregoing, arsenic has been used in a great variety of diseases on the general principle of being an "alterative," with alleged success in many cases.

2. The Preparations of Arsenic Used in Medicine.—The arsenical compounds used in medicine are the *trioxide* (arsenous acid), *triiodide*, and the two salts, *potassium arsenite* and *sodium arsenate*.

Arsenic Trioxide, As_2O_3, or As_4O_6. This well-known compound is official in the U. S. P. as *Acidum Arsenosum*, Arsenous Acid, an appellation which chemically belongs only to the aqueous solution of the oxide. This is the preparation known also as *white arsenic*, or, in common parlance, simply *arsenic*. Arsenous acid, so-called, is "a heavy solid, occurring either as an opaque, white powder, or in irregular masses of two varieties: the one amorphous, transparent and colorless, like glass; the other crystalline, opaque or white, resembling porce-

lain. Frequently the same piece has an opaque, white, outer crust enclosing the glassy variety within. Contact with moist air gradually changes the glassy into the white, opaque variety. Both are odorless and tasteless. In cold water both varieties dissolve very slowly, the glassy variety requiring about 30, the porcelain-like about 80 parts of water at 15° C. (59° F.). Both are slowly but completely soluble in 15 parts of boiling water. In alcohol, arsenous acid is but sparingly soluble, but it is soluble in about 5 parts of glycerin. Oil of turpentine dissolves only the glassy variety. Both varieties are freely soluble in hydrochloric acid, and in solutions of alkali hydrates and carbonates. When heated to 218° C. (424.4° F.), arsenous acid is completely volatilized without melting. When thrown on ignited charcoal, it emits an alliaceous odor. When its vapor is passed through red-hot charcoal, in an arsenic tube, it is deoxidized, and metallic arsenic is deposited on the cooler portion of the tube as a mirror having a metallic lustre. An aqueous solution of arsenous acid has a faintly acid reaction upon litmus paper" (U. S. P.). Arsenous acid is obtained by sublimation, by roasting ores containing arsenic, and is subsequently purified by resublimation. When first obtained it is in transparent glass-like masses, but these, in after-exposure, acquire the porcelain-like appearance in which arsenous acid is commonly met with in the shops. This change, beginning on the surface, gradually extends in time throughout the whole thickness of the mass; not so quickly though but what commercial samples may often be found where the masses, on fracture, show a vitreous interior. For medical use the mineral is pulverized, appearing then as a very fine, white, smooth powder. In this condition it is easily adulterated, but the fraud can readily be detected by submitting the sample to sublimation, when the arsenous acid will all disappear by volatilization, and the impurities be declared by a non-volatile residue.

Arsenous acid possesses all the physiological properties of arsenicals, as set forth above. It does not act upon the sound skin, but upon a mucous membrane or denuded surface produces violent irritation. Taken internally it is capable of sufficient absorption to produce the constitutional effects of arsenic, therapeutic or toxic, and so may be used as a medicine, in doses of 0.003 gm. (gr. $\frac{1}{20}$) three times a day, generally given in pill. But it is not an eligible preparation for internal use, because of the local irritation it is apt to set up. Externally it has been employed to destroy the tissues of cancer or lupus, applied in ointment or paste. For such purpose the arsenous acid is mixed with from four to eight times its weight of inert matter, such as ointment or a paste made of some indifferent powder mixed with mucilage. Such arsenical ointment or paste is then applied to the tissue to be destroyed, the point being observed, if the part be covered by skin, first to remove the epithelium by blistering. The application is to continue for from twelve to twenty-four hours. Weak arsenical mixtures are more dangerous than strong, because of the greater likelihood of constitutional poisoning. Even strong applications, if at all extensive, are risky, and at best the destruction of tissue by arsenic is a slow, uncertain, and very painful process, not to be commended. Most of the numberless caustic pastes of quack "cancer doctors" are preparations of arsenous acid. The following have been celebrated in their day: *Arsenical Paste of Frère Côme:* Arsenous acid and animal charcoal, each one part; mercuric sulphide, four parts; to be used only over a small area at a time. *Sir Astley Cooper's Arsenious Ointment:* Arsenous acid and sulphur, each 1 part; spermaceti cerate, 8 parts. *Plunket's Caustic:* Bruised plant of *ranunculus acris* and of *ranunculus flammula*, each 24 parts; arsenous acid, 3 parts; sulphur, 5 parts; the whole mixed to a paste, rolled into balls, and these dried in the sun. For application the balls are again to be reduced to pasty consistence by rubbing with yolk of egg. In using this preparation, preliminary denudation of the skin is unnecessary, that operation being performed by the acrid matter of the crowfoot. The only preparation of arsenous acid official in the U. S. P. is what is entitled *Liquor Acidi Arsenosi*, Solution of Arsenous Acid. This is a one-per-cent. solution of the arsenical in water slightly acidulated with hydrochloric acid. The preparation is of the same strength as Fowler's solution (see below), and is given in doses of 0.30 gm. (♏ v.) three times a day, largely diluted with water.

Arsenic Triiodide, AsI_3. This compound is official in the U. S. P. as *Arseni Iodidum*, Arsenic Iodide. It is in "glossy, orange-red, crystalline masses, or shining, orange-red, crystalline scales, having an iodine-like odor and taste, and gradually losing iodine on exposure to air and light. Soluble at 15° C. (59° F.) in 7 parts of water and in about 30 parts of alcohol; also soluble in ether, and in carbon disulphide. The salt is gradually decomposed by boiling water and by boiling alcohol. By heat it is completely volatilized, and if it be heated with diluted nitric acid, vapor of iodine will be evolved. The aqueous solution of the salt has a yellow color, is neutral to litmus paper, and, on standing, gradually decomposes into arsenous and hydriodic acids" (U. S. P.). This iodide has been given internally as an arsenical in doses of 0.008 gm. (gr. $\frac{1}{8}$), and used externally on malignant growths in a one-per-cent. ointment; but its principal purpose among medicines is to furnish the pharmacist with the arsenical ingredient of the official preparation, *Liquor Arseni et Hydrargyri Iodidi*, Solution of Arsenic and Mercuric Iodide, commonly known as *Donovan's Solution*. This is an aqueous solution of one per cent. each of arsenic iodide and red mercuric iodide. It is a pale yellow fluid, slightly astringent in flavor, and precipitating with alkalies, silver solutions, and solutions of alkaloidal salts. It is used as a composite "alterative" internal medicine, its reputation being principally in the line of scaly skin disease, syphilitic or idiopathic, and in rheumatic affections. Dose, from five to ten drops, well diluted with water, after meals.

Potassium Arsenite. An arsenite of potassium is official in the U. S. P. only in the solution entitled *Liquor Potassii Arsenitis*, Solution of Potassium Arsenite, better known by the common name of *Fowler's Solution*. This solution is made by boiling 1 part of arsenous acid and 2 of acid potassium carbonate in water until chemical union is effected, then bringing the solution to the standard strength of one per cent. of arsenous acid, and adding a small charge of compound tincture of lavender. This latter addition is to give the preparation sufficient taste and color to prevent its being mistaken for simple water. Fowler's solution is clear, and tastes only of lavender. It responds to the usual tests for arsenic. Physiologically it acts the same as would a solution of arsenous acid of like strength. It is in imitation of a famous remedy known as "tasteless ague drop," and is the most convenient and commonly used arsenical for internal giving. The average dose is five drops, well diluted with water, to be taken, like all arsenicals, after eating, and repeated two or three times a day.

Sodium Arsenate, $Na_2HAsO_4+7H_2O$. The salt is official under title *Sodii Arsenas*, Sodium Arsenate. It occurs in "colorless, transparent, monoclinic prisms, odorless, and having a mild, alkaline taste (the salt is very poisonous). Efflorescent in dry air, and somewhat deliquescent in moist air. Soluble in 4 parts of water at 15° C. (59° F.), and very soluble in boiling water; very sparingly soluble in cold, but soluble in 60 parts of boiling alcohol. When gently heated, the salt loses five molecules of water (28.8 per cent.), and is converted into a white powder. At 148° C. (298.4° F.), the rest of the water of crystallization is lost, the salt fuses, and at a red heat is converted into pyroarsenate. It imparts an intense, yellow color to a non-luminous flame" (U. S. P.). Sodium arsenate has the usual properties of the arsenicals, but is a little milder than potassium arsenite.[1] It is generally prescribed in the official *Liquor Sodii Arsenatis*, Solution of Sodium Arsenate, which is simply a one-per-

cent. aqueous solution of the salt. This solution may be **given in the same dose and manner as** Fowler's solution.

Edward Curtis.

[1] **Th. Gies:** Archiv für experiment. Path., December, 1877, quoted in Phillips's Materia Medica.
[2] **Maclagan:** Edinburgh Medical Journal, 1864, p. 203.
[3] **Ringer:** Journal of Physiology, vol. i., p. 213.

ARTERIES, ANOMALIES OF.—Arteries are subject to frequent variations of size, origin, and distribution. Some of these are so common that it is difficult to decide what is the normal condition. Many anomalous arteries are merely a persistence of an early fetal condition, others are reversions to forms of distribution which are natural in the various species of the lower animals, while some are due to an abnormal enlargement or diminution of vessels which naturally exist. I propose in the present article chiefly to describe those anomalies which are important surgically—that is, those which exist in parts liable to diseases which necessitate a surgical operation for their cure or relief. However interesting would be a consideration of anomalies of arteries from a morphological point of view to pure anatomists, I fear the subject is not of sufficient interest to the general profession to justify me in devoting much space to it here.

AORTA.—This vessel is subject to many variations. It may vary in length and position. The summit of the arch has been seen as high as the top of the sternum and as low as the fifth dorsal vertebra. The distance to which it reaches on the spine before dividing into the two common iliacs also varies, the point of division being occasionally as low as the fifth, and as high as the third, or even the second, lumbar vertebra. The aorta has been seen consisting of two closely united tubes, in part or the whole of its course, due to a persistence of the original double aorta of early fetal life (Fig. 288). The aorta is sometimes very tortuous, of large size, and displaced to one side, especially in old people, but this condition is due more to pathological changes than to congenital malformation.

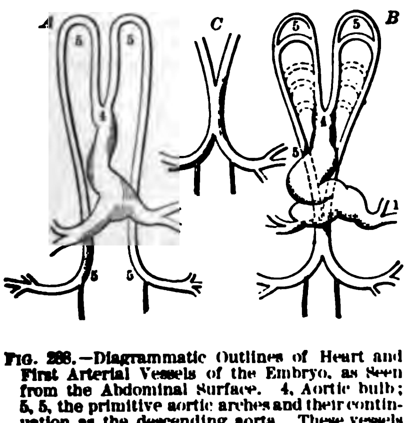

FIG. 288.—Diagrammatic Outlines of Heart and First Arterial Vessels of the Embryo, as Seen from the Abdominal Surface. 4, Aortic bulb; 5, 5, the primitive aortic arches and their continuation as the descending aorta. These vessels are separate in their whole extent in *A* (38 to 88 mm. in thickness), but at a later period, as shown more fully in *C*, have coalesced into one tube in a part of the dorsal region. In *B*, below upper 5, the second aortic arch is formed, and farther down the dotted lines indicate the position of the succeeding arches, numbering five in all. (Quain's "Anatomy.")

The main trunks of the *aorta* and pulmonary artery are (4, Fig. 288) both derived from the arterial bulb of the fetal heart, "and are liable to variations which may be traced to deviations from the natural mode of their septal division and of their union with the left or right ventricles of the heart respectively" (Quain's "Anatomy"). These variations are generally associated with malformations of the heart, and often with patency of the ductus arteriosus. The aortic or pulmonary trunk may be almost obliterated, or the two trunks may communicate freely with each other, owing to the failure of complete septal division; again, their origins may be transposed, the pulmonary artery arising from the left ventricle and the aorta from the right. A very rare anomaly has been reported where the pulmonary artery and aorta form one stem which arises from a simple heart like that seen in fishes. A few cases are reported in which the descending aorta arose from the pulmonary artery and gave off the left subclavian, the left ventricle giving off only the innominate and left carotid. Most of these varieties are incompatible with life, and are fully described in works on pathological anatomy.

Varieties of the Aortic Arch.—The various anomalies of the aortic arch depend on the mode of development of the fourth and fifth fetal branchial arches. In man and nearly all mammalia the arch is a left one, produced by the persistence of the fourth left branchial arch (Fig. 289). In birds the permanent aorta is formed from the right fourth branchial arch; and in reptiles both the right and left fourth branchial arches are persistent. In cases in which there is transposition of the heart, and also, of course, of the arch of the aorta, the aorta is a right one, instead of the usual left, and this is owing to the persistence of the right fourth branchial arch, as in birds. The pulmonary artery in these cases is also transposed and is formed from the right fifth arch in place of from the left. Many of these cases have been reported and have been diagnosed during life, the direction of the apex of the heart being toward the right, the apex beat being felt on the right side between the fifth and sixth ribs. A very good specimen of this anomaly is to be seen in the museum of the Pennsylvania Hospital in Philadelphia.

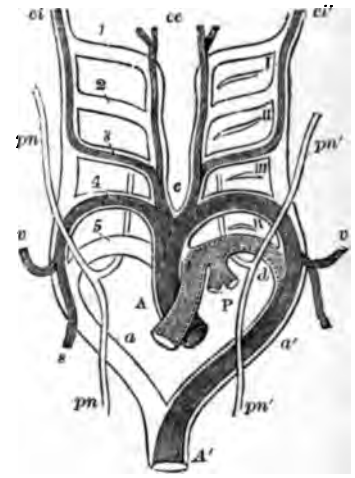

FIG. 289.—Diagram of the Fetal Aortic Arches, Showing Their Transformation into the Permanent Vessels of the Mammal. (After Rathke.) The permanent vessels are represented by the deep shading, the pulmonary arteries lighter, the temporary primitive arches in outline only. A, P, Primitive aortic stem, divided into A, aortic arch, P, pulmonary artery; *a*, right aortic root; *a'* left aortic root; *A'*, descending aorta; 1, 2, 3, 4, 5, primitive vascular arches; *pn*, *pn'*, right and left pneumogastric nerves; *v*, *v'*, right and left vertebrals; *s*, *s'*, right and left subclavians; *ce*, external carotids; *ci*, *ci'*, internal carotids. (From vol. ii., Quain's "Anatomy.")

Occasionally the aortic arch has been observed completely double (Fig. 290), as in reptiles, due to the persistence of both right and left aortic roots (*a*, *a'*, Fig. 289) and the fourth branchial arches of both sides. The double aorta embraces the trachea and œsophagus, and unites below to form a single trunk on the left side of the spinal column, as in early fetal life (*B*, Fig. 288).

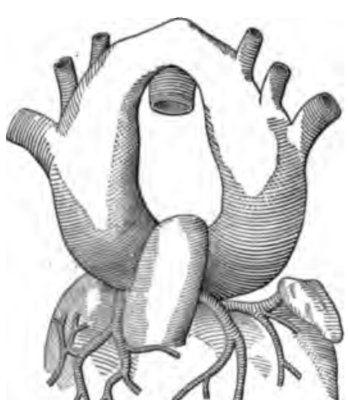

FIG. 290.—Example of a Double Ascending Aorta, from the Arch of Which Arise Six Branches—Two Subclavian and Four Carotid Arteries. (After Malacarne.)

The aorta may pass to the right of the trachea and œsophagus instead of to the left, and this without the transposition of the heart mentioned above. If we study the fetal conditions the explanation of this anomaly is easy. It is a persistence of the right fourth branchial

arch and aortic root instead of the left (Fig. 289). In these cases the recurrent laryngeal nerve of the left side hooks round the subclavian, and that of the right around the arch of the aorta. In some of the cases of right arch that have been observed the left subclavian arose from the back part of the descending aorta, passed behind the trachea, and reached its usual position in the neck between the scalene muscles. In cases of this kind, the first part of the subclavian being absent, owing to the non-development, or rather obliteration, of the fourth left vascular arch, the inferior laryngeal nerve does not hook around it, but goes directly to the larynx, and the vertebral artery may arise directly from the arch.

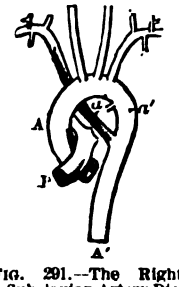

FIG. 291.—The Right Subclavian Artery Displaced or Proceeding from the Right Aortic Root. A, A', ascending and descending portion of the thoracic aorta; a, right aortic root persisting as the subclavian artery; a', left aortic root; P, pulmonary artery. (Quain's "Anatomy.")

Variations in Number and Position of the Branches of the Arch of the Aorta.—These variations are very numerous; I shall mention only the most common and important. The branches of the aortic arch may be given off from a single trunk, which forms what is called the anterior aorta. This arrangement is seen in the horse. The commonest abnormal arrangement of the branches is that where the left carotid arises from the innominate; thus only two branches are given off from the arch, the left subclavian and the innominate. This is the usual distribution in most of the carnivora. There may be two innominates given off from the arch, each dividing into a carotid and subclavian, as in the bat. Three branches is the normal number arising from the arch in man, apes, and a few other animals. Occasionally we see three branches arising from the arch in a different way from the normal. We may have the two subclavians arising separately, and the two carotids arising from a common stem between them. This is the normal disposition in some cetacea. Sometimes all four vessels arise separately from the arch. Again, the left vertebral may arise from the arch, while the other branches preserve the normal arrangement, or there may be five branches given off separately, viz., the two subclavians, two carotids, and left vertebral. As many as six branches have been seen to come off from the aortic arch. This occurs when, in addition to the above-mentioned five branches, the right vertebral is also given off. A curious anomaly, and one which is interesting from its rarity and manner of development, is that form of arch where the right and left carotids and left subclavian arise separately from the arch, and the right subclavian arises from the back part of the descending aorta, passes behind the trachea and œsophagus and ascending portion of the arch, and reaches its normal place between the scalene muscles (Fig. 291). In this case the right inferior laryngeal nerve, instead of hooking round the subclavian, passes directly to the larynx. The subclavian here represents the persistent right aortic root, and the right fourth branchial arch is obliterated (see Fig. 289). Some years ago I met with a curious anomaly having somewhat this character. I looked upon it as a double subclavian. The right subclavian was given off as usual from the innominate, but was joined in the second part of its course, between the scalene muscles, by a small branch which arose from the back part of the descending aorta. I considered this a case of persistence of the fourth right vascular arch, and also of the right aortic root (Fig. 292). (For a complete description of the very many varieties of the arch of the aorta, see Turner on "Varieties of the Arch of the Aorta," in *Brit. and For. Med.-Chir. Rev.*, 1862; Henle's "Anatomy," vol. iii.; Hyrtl; and Professor Struthers.)

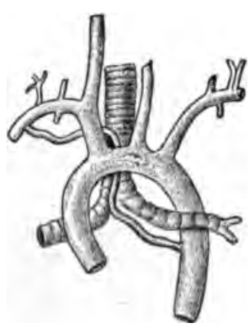
FIG. 292. Right Aortic Root Persisting as a Small Branch Which Connects the Descending Aorta with the Subclavian. May be regarded as an example of double subclavian.

INNOMINATE, OR BRACHIO-CEPHALIC.—This artery occasionally varies as to the point of its division. In some cases it divides above the sterno-clavicular articulation, and in others considerably below it. When there is a high division, there is danger of its being wounded in tracheotomy, especially in those cases in which the artery inclines to the median line. In cases of ligature, however, the operation would be much facilitated by a high division, and rendered much more difficult by a low one.

The *thyroidea ima* or *middle thyroid* (Fig. 293) is not infrequently given off from the innominate, and ascends to its destination in front of the trachea. When present it would complicate the operations of tracheotomy and excision of the thyroid gland. In observations made by myself on 250 subjects, I found that this artery occurred 12 times, or once in 20.83 cases. Richard Quain, in his valuable work on the arteries, found it 9 times in 291 subjects, or once in 32.33. It is sometimes of large size, dividing into two branches, one of which goes to each lobe of the thyroid gland.

This artery sometimes arises from the right common carotid, and rarely from the arch of the aorta between the left carotid and innominate.

COMMON CAROTID ARTERIES.—These vessels may vary in their origin and place of division. The *right carotid* occasionally arises directly from the arch of the aorta either alone or with the left carotid. In the latter case the artery, to reach its usual position on the right side, crosses the trachea above the upper border of the sternum, a fact worth remembering in connection with the operation of tracheotomy. It may arise above or below the sterno-clavicular articulation, according as the innominate is longer or shorter than usual. The *left carotid* varies more frequently in origin than the right, as it is derived from the innominate in about one case in nine. It may also arise from the arch in common with the right carotid.

FIG. 293.—Showing a Middle Thyroid Artery (T. I.) Arising from the Innominate and Running up the Front of the Trachea to Supply the Thyroid Gland. (From R. Quain, slightly altered.)

Place of Division.—The common carotid often varies as to its place of division. The normal dividing point is opposite the upper border of the thyroid cartilage, but it sometimes divides as high up as the hyoid bone, and as low down as the cricoid cartilage. Morgagni reports a case in which it divided at the root of the neck. Cases are recorded in which it did not divide at all, one or other of its main branches being absent. I have occasionally seen this artery give off the superior thyroid and ascending pharyngeal before its division, and also a small laryngeal. I also once saw the left carotid giving off the left vertebral.

EXTERNAL CAROTID AND ITS BRANCHES.—As mentioned above, the origin of the external carotid varies considerably. It has in rare cases been noticed arising from the innominate, and even from the arch of the aorta itself. Absence of this artery has been met with, the branches arising at varying intervals from a common trunk, representing both internal and external carotids. The artery sometimes passes between the digastric muscle and stylo-hyoid. I have in one case seen it pass up to the parotid gland superficial to both the posterior belly

of the digastric and the stylo-hyoid, instead of behind them.

The origin of the branches varies considerably; they may be crowded together at the commencement of the vessel, or at a point higher up. Sometimes they arise from the main trunk at nearly regular intervals, and occasionally we find several branches arising from a single stem. Accessory arteries may arise from the external carotid, such as the accessory superior thyroid and accessory ascending pharyngeal. The sterno-mastoid, which usually arises from the occipital, occasionally arises from the main trunk, and when this occurs the hypoglossal nerve hooks around this small branch instead of around the occipital. In consequence of the lower origin of the sterno-mastoid, the nerve in such cases passes lower down the neck before crossing the vessels to reach the hyoglossus muscle.

Superior Thyroid.—This vessel may be very small or absent, its place being taken by the artery of the opposite side and the inferior thyroid of the same side. It sometimes arises from the common carotid. The *crico-thyroid* may be of considerable size, and its *superior laryngeal* branch may arise from the main trunk, or pierce the thyroid cartilage instead of the thyro-hyoid membrane, as is the case in many mammals. Mr. Walsham ("St. Bartholomew's Hosp. Rep.," 1880) has several times met with a large branch from the superior thyroid crossing the trachea between the cricoid cartilage and isthmus of the thyroid. He once wounded it in performing tracheotomy.

Lingual.—This artery often arises in common with the facial, and occasionally with the superior thyroid. Instead of passing beneath the hyoglossus muscle it has been seen to pierce it.

In some rare cases it has been absent, and its place has been taken by a branch from the internal maxillary. Its place has been taken also by a branch from the facial, the submental. Its sublingual branch is occasionally derived from the facial. The hyoid branch is often wanting, and in such cases the hyoid branch of the superior thyroid takes its place. The lingual sometimes gives off the submental and ascending palatine artery. In one case of operation on the dead subject, the writer could not find the artery in the usual place, but it was found coming off from the superior thyroid, passing up to the median line of the neck on the thyro-hyoid muscle. It crossed the hyoid bone internal to the lesser cornu, pierced the hyoglossus muscle, and thence onward its course was normal (*Annals of Surgery*, vol. ix., 1889, p. 33).

Facial.—This artery is very variable in size and also in extent. When the facial is deficient its place is taken by the transverse facial, internal maxillary, or ophthalmic, most frequently the first mentioned.

Occipital.—This artery usually arises opposite the facial, but its place of origin may be above or below this point. Sometimes it is derived from the internal carotid or the ascending cervical branch of the inferior thyroid. It occasionally passes to its destination superficial to the trachelo-mastoid muscle, or it may pierce the sterno-mastoid and splenius capitis muscles. R. Quain mentions a case in which it passed superficial to the sterno-mastoid muscle. It not infrequently gives off the posterior auricular and ascending pharyngeal.

Posterior Auricular.—Often a branch of the occipital; sometimes of small size, ending in the sterno-mastoid muscle.

Ascending Pharyngeal.—Varies greatly in its place of origin; may arise from the internal carotid, occipital, or a linguo-facial branch. It is occasionally double.

Superficial Temporal.—This vessel is very often tortuous, especially in the aged.

The *transverse facial* is occasionally of large size, and takes the place of the facial. It is sometimes double.

Internal Maxillary.—This artery frequently arises in common with the temporal. R. Quain has observed it in two instances arising from the facial, "from which it coursed upward, to pass beneath the ramus of the maxillary bone in the usual situation."

It very frequently (in about 4.5 per cent.) is covered by the external pterygoid muscle, instead of lying superficially to that muscle. It sometimes perforates the external pterygoid, and rarely the internal. It may replace the facial by a branch from the posterior dental, buccal, or infra-orbital artery.

Internal Carotid and Its Branches.—This artery in the neck is occasionally very tortuous. It has been known to be absent, its place being taken by the artery of the opposite side or by a branch from the internal maxillary. It is sometimes very small, smaller than the vertebral (Hyrtl). The ascending pharyngeal, occipital, lingual, or transverse facial may arise from the internal carotid.

A large communicating branch has been seen going from this artery, while in the cavernous sinus, to the basilar artery; in such a case the posterior communicating branch is wanting. The posterior cerebral not infrequently comes off from one of its branches, the posterior communicating.

Ophthalmic Branch.—This has been seen to come off from the middle meningeal artery. Occasionally the middle meningeal comes off from the ophthalmic. The ophthalmic may, by its nasal branch, supply a deficiency in the facial. In fifteen per cent. of cases it crosses beneath instead of over the optic nerve. It has been seen to go through the sphenoidal fissure.

Cerebral Arteries.—The *anterior cerebral* of one side is often much larger than that of the other. In some rare cases the two anterior cerebral arteries are united into a common trunk, like the basilar. The *anterior communicating* artery is sometimes double; I have once seen it treble. It is often very short. The *posterior cerebral* may arise from the internal carotid by a large posterior communicating. It has been seen by Hyrtl to give off the middle cerebral.

The *posterior communicating* artery occasionally comes off from the middle cerebral instead of from the internal carotid.

Subclavian.—The varieties of origin of this artery have already been mentioned in the account of the anomalies of the arch of the aorta and innominate artery. It is generally given off from the innominate on the right side, opposite the sterno-clavicular articulation, but occasionally the innominate reaches nearly as high up as the cricoid cartilage before it divides, and in these cases the artery would be at an unusually high level. The highest part of the artery is the second portion, and it is normally about 1.2 to 2.7 cm. (one-half to three-quarters of an inch) above the clavicle, with the shoulder depressed, but not infrequently it may be below, or on a level with, the clavicle, and sometimes, especially on the right side, it may be placed as high as 3.7 cm. (one inch and a half) above the level of the clavicle. It may, in those rare cases in which a cervical rib is attached to the seventh cervical vertebra, pass over this rib in place of the first dorsal, and be raised fully two inches above the clavicle. I have seen this occur once in two hundred and fifty subjects examined. In the living, when this condition exists, it may be, and has been, mistaken for aneurism. Sir James Paget has diagnosed this anomaly four times during life. It is obvious that the height to which the artery reaches is important in cases in which ligature is necessary. I have seen in one case in which there was an incomplete left first rib the artery pass over the second rib. On the right side there was also a rudimentary first rib completed by fibrous tissue. There was a deep groove in this rib, in which rested the artery; before complete dissection this was taken for a cervical rib. The cases for which ligature is undertaken are chiefly those of aneurism of the axillary artery, in which, in consequence of the condition of the parts, the shoulder is elevated. If the artery should be at an unusually low level, or even just behind the clavicle, the operation, as may be conceived, would be rendered extremely difficult.

The third part of the artery in thin people with small muscles is very superficial, but in stout, muscular individuals it is very deeply placed. Dupuytren says: "The

third part of the subclavian lies near the skin in those who are thin and have slender and long necks, with lean and pendent shoulders; it is, on the contrary, deeply hidden in persons who have short, thick necks and muscular shoulders."

Occasionally the subclavian artery pierces the scalenus anticus instead of going behind it, and more rarely passes entirely in front of the muscle; of the first variety I have seen five cases in two hundred and fifty subjects (three on the left and two on the right side); of the second, in the same number of subjects examined, I have seen only one example.

The vein may pass with the artery behind the anterior scalenus, and in very rare cases their normal positions may be reversed. The trapezius may cover the third part of the subclavian, or it may have in front of it the omo-hyoid muscle. These conditions, however, will be more fully described under *Muscles, Anomalies of*.

Variations of Branches.—It is important, surgically speaking, that the position of the various branches given off from the subclavian should be considered.

The branches given off from the first part do not, as a rule, vary much in their arrangement, but several may be transferred to the second or third portions. The left vertebral may arise from the arch of the aorta instead of from the first part of the left subclavian, and the branches of the thyroid axis may be given off separately.

The first part of the right subclavian, having been occasionally ligated, it is necessary to know at what distance from the innominate the branches arise. In the majority of cases this is from 1.25 cm. (half an inch) to 2.4 cm. (one inch) (R. Quain); but it often exceeds this, and is frequently 2.4 cm. (one inch) to 3.8 cm. (one inch and three-quarters). In a small minority of cases the distance is under 1.2 cm. (half an inch).

In the *second portion of the artery*, one branch, as a rule, is given off, the superior intercostal; occasionally no branches are seen here, and again, not infrequently, there are two or three.

The *third portion*, in a little more than half the cases, gives off no branch, in a little less than half, one branch, occasionally two, and in very rare cases three and four.

Vertebral Artery.—Origin: The right vertebral, in those rare cases in which the right subclavian arises from the arch of the aorta, is given off from the common carotid of the right side. The right vertebral has been seen coming from the arch.* The left vertebral not infrequently is given off from the arch of the aorta, generally between the left carotid and left subclavian. I have seen this arrangement twelve times in two hundred and fifty subjects. I have once seen it come off from the left common carotid. The vertebral has been seen with two, and even three roots (R. Quain).

Course: This vessel may fail to enter the transverse process of the sixth cervical vertebra, but continue up the neck between the inferior thyroid artery and vein to enter the transverse process of any of the vertebræ from the fifth to the second. It is not uncommon for it to enter the transverse process of the fourth or fifth vertebra, but it is only very occasionally that it passes up as high as the third and second before entering the foramen. Again, it may enter the transverse process of the seventh cervical vertebra, instead of the sixth.

Size: The left vertebral is frequently much larger than the right, especially in those cases in which it is given off directly from the arch of the aorta. Sometimes the vertebral is nearly as large as the common carotid, at other times as small as the ascending cervical branch of the inferior thyroid.

Branches: The vertebral may, as a very rare occurrence, give off the inferior thyroid or superior intercostal artery. I have seen two examples of the first variety occurring on both sides of same subject. Its inferior cerebellar branch is frequently absent on one side.

The *thyroidea ima* has been observed in rare cases to come off from the right subclavian.

The upper end of the vertebral artery occasionally divides into two branches, which unite a little higher up, thus forming a loop through which pass filaments of the hypoglossal nerve. I have seen this anomaly in two instances.

Thyroid Axis.—This trunk occasionally arises beyond the scalenus anticus muscle (according to R. Quain twice in two hundred and seventy three cases). It not infrequently gives origin to the internal mammary. It is sometimes absent, its branches being given off separately from the subclavian.

Inferior Thyroid.—This artery frequently arises as an independent branch from the subclavian. It has been seen to arise from the common carotid, and not infrequently from the vertebral. It varies considerably in size, and when small its place is taken by the superior thyroid. In cases of enlarged thyroid gland (bronchocele) it is often nearly as large as the carotid. Two inferior thyroids have been found on the same side, one having the normal course beneath the carotid artery, and the other reaching its destination by passing superficially to that vessel (Fig. 294). Its branches of division are closely connected with the recurrent laryngeal nerve, which may pass beneath or above them, a point to be borne in mind in extirpation of the thyroid gland. The inferior thyroid

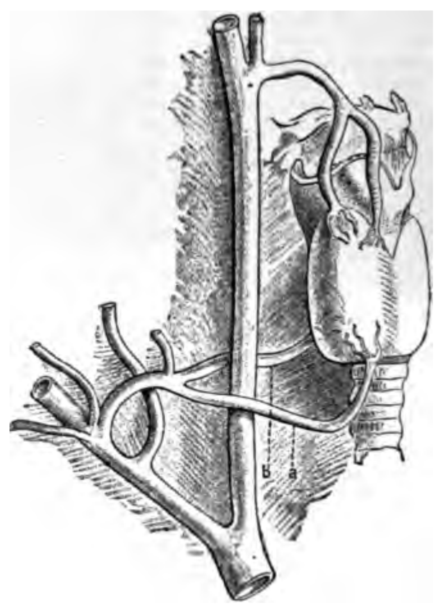

FIG. 294.—Inferior Thyroid Artery Dividing into Two Branches, one (b) of which (a) passes in front of the carotid sheath, the other behind it. (Anderson: *Jour. Anat. and Phys.*, vol. xiv.)

may be wanting altogether, its place being supplied by an enlarged superior thyroid of the same side.

The *ascending cervical* branch of the inferior thyroid may be derived directly from the subclavian or one of its branches. It is occasionally of large size, and may take the place of the occipital.

Suprascapular.—This artery is usually derived from the thyroid axis, but not infrequently has a different origin. It is often given off directly from the subclavian. It may be given off from the internal mammary. I have several times seen it derived from the subscapular and also from the axillary. It is often very small.

Transverse Cervical.—This artery when given off from

* Mr. A. M. Paterson (Jour. Anat. and Phys., April, 1884) records a case of right vertebral arising from the aortic arch beyond the left subclavian, and reaching the vertebro-arterial canal by passing behind the trachea and œsophagus; in fact, following exactly the course of the subclavian when it arises from the back part of the arch, as figured above. Mr. Paterson regards this anomaly as a persistence of the right aortic root, with obliteration of the connection between the subclavian and vertebral arteries where they cross.

the thyroid axis divides into two terminal branches, viz., the superficial cervical and posterior scapular. Very often the superficial cervical only is given off from the thyroid axis, the posterior scapular coming off as a separate branch from the second or third part of the subclavian, rarely from the first part. It is well, when ligaturing the third part of the subclavian, to remember that the posterior scapular comes off from it about once in every three cases. When the posterior scapular artery is given off from the third part of the subclavian I have not infrequently seen it pierce the fibres of the scalenus medius muscle, and occasionally go between the cords of the brachial plexus. The posterior scapular artery may be given off from the axillary, or it may end near the scapula in a small branch, its place being supplied by branches from the suprascapular. The superficial cervical may come off from the subclavian as a separate branch, the posterior scapular alone being derived from the thyroid axis. When the posterior scapular is a branch of the third part of the subclavian it often gives off a large branch to supply the trapezius, which represents the greater part of the superficial cervical, the latter artery in such cases being very small or absent.

The transverse cervical artery is occasionally given off from the subclavian as a separate branch.

Internal Mammary.—This is a large and very regular branch of the subclavian, generally arising from the lower part opposite the vertebral. It may arise from the thyroid axis, axillary, or innominate, or even from the arch of the aorta. It may also form a common trunk with either of the scapular arteries, and be given off from the second or third part of the subclavian. Hyrti describes a case in which the trunk of this artery crossed in front of the fifth right costal cartilage, coming out of the thorax through the fourth interspace and re-entering it by the fifth. In one case the author saw the phrenic nerve pierced by this artery.

A branch is sometimes given off from the upper part of the internal mammary, called by Henle the *A. mammaria interna lateralis*, which crosses the inner surface of the upper four to six ribs and intercostal spaces at right angles, about midway between the spine and sternum, anastomosing in its course downward and outward with the intercostal arteries. In penetrating wounds of the thorax, fractured ribs, and other injuries, this lateral branch might be wounded and give rise to dangerous hemorrhage. It might also be wounded in the operation for evacuating an empyema.

Superior Intercostal.—Sometimes arises from the thyroid axis or vertebral. I have seen it arise from the internal mammary. It may be of considerable size, and may supply three or four intercostal spaces. It in some cases passes between the neck of the first or second rib and the corresponding transverse process of the dorsal vertebra. It is very rarely absent.

Deep Cervical.—This artery is generally a branch of the preceding, but occasionally is derived directly from the subclavian, in the proportion of 1 in 20 subjects (R. Quain). In rare cases it arises from the posterior scapular and internal mammary. It is not infrequently of small size, its place being taken by the deep cervical branch of the occipital, a branch of the inferior thyroid, the ascending cervical or a posterior cervical branch of the transverse cervical (Henle).

It may pass between the transverse processes of the fifth and sixth cervical, first and second dorsal, or second and third dorsal instead of between the seventh cervical transverse process and first rib.

There is sometimes an accessory branch accompanying it.

Axillary Artery.—The most important anomaly of this vessel is its early division into two trunks, one of which may give off all or most of the branches, or may be a high origin of the radial, ulnar, or even the interosseous artery (Fig. 295). When one of the trunks gives off all or most of the branches it is nearly always surrounded by the brachial plexus of nerves and embraced by the two heads of the median. The branches given off from this common stem may vary. I have seen it give origin to the acromial thoracic, long thoracic, anterior and posterior circumflex, subscapular, and one or both of the profunda arteries of the arm; the anterior and posterior scapular with the subscapular arteries not infrequently come from a common stem. This arrangement of the branches of the axillary occurs normally in many animals, *e.g.*, the lemur, tapir, peccary, dolphin, etc., and much resembles that which takes place in the lower extremity, viz.: the common femoral dividing into a superficial and a deep branch, the deep giving off all the branches, and the superficial going down the extremity branchless. According to Richard Quain, this variation occurred 28 times in 506 arms examined. I have met with it only 15 times in 500 arms in which the arrangement of the axillary was observed. Quain gives the proportion of cases in which one of the arteries of the forearm is derived from the axillary as 23 in 506; Gruber, 21 in 1,200. I have found this condition to exist 12 times in 500 arms examined.

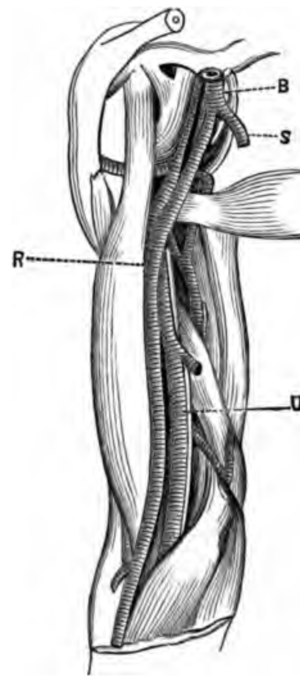

FIG. 295.—Origin of Radial (R) from the Axillary (B). (After Reeves.)

The radial is the branch most frequently given off in these cases, next the ulnar, and very rarely the interosseous. I have only once seen the interosseous arise from the axillary.

An aberrant artery is occasionally found arising from the axillary; it generally courses down the arm alongside the brachial, which it joins near the elbow. Sometimes this aberrant vessel joins the radial, ulnar, or interosseous artery near the wrist. One remarkable case came under my observation some years ago in which this aberrant artery passed down the arm superficial to the fascia, in the forearm followed the course of the median nerve, communicated with the radial by several transverse branches, and finally ended by taking the place of the superficial volar, completing the superficial palmar arch (Fig. 296).

The most constant branch of the axillary is the long thoracic or external mammary; this, or a representative of it, is nearly always seen running along the lower border of the pectoralis minor muscle; it, however, not infrequently arises from the thoracic axis and occasionally from the subscapular. There may also be an accessory external mammary. The subscapular and circumflex branches frequently arise together. The dorsalis scapulæ, instead of being derived from the subscapular, may arise directly from the axillary.

The posterior circumflex occasionally fails to enter the quadrilateral space (formed by the humerus, subscapularis muscle, long head of triceps, and teres major), but reaches the deltoid muscle by winding round the lower border of the tendons of the latissimus dorsi and teres major muscles. It not infrequently arises from the superior profunda, and is sometimes double. In rare cases the internal mammary, posterior scapular, or suprascapular may arise from the axillary.

Brachial Artery.—The variations in the course, re-

lations, and distribution of this artery are very numerous and of special surgical interest.

Course: The brachial artery sometimes, accompanied by the median nerve, courses down the arm to the internal condyle of the humerus, and thence regains its normal position at the bend of the elbow, by passing forward under a fibrous or bony arch. This arch is formed, usually, partly by bone and partly by ligament; the bony process is called the supracondyloid and the foramen, which is completed by a ligament from the tip of the process to the internal condyle, the supracondyloid foramen. In these cases it is usual to have a high origin of the pronator radii teres muscle from the supracondyloid process. This arrangement is said to be more common in dark races, and is the normal one in all the cat tribe and in monkeys, lemurs, and sloths. In these animals the foramen is nearly always completed by bone, and affords protection to the median nerve and artery during flexion of the fore-limb, and also affords them a more direct course to the fore-limb. In man the artery may occasionally take this course without there being present a supracondyloid process; there may be only a high origin of the teres muscle.

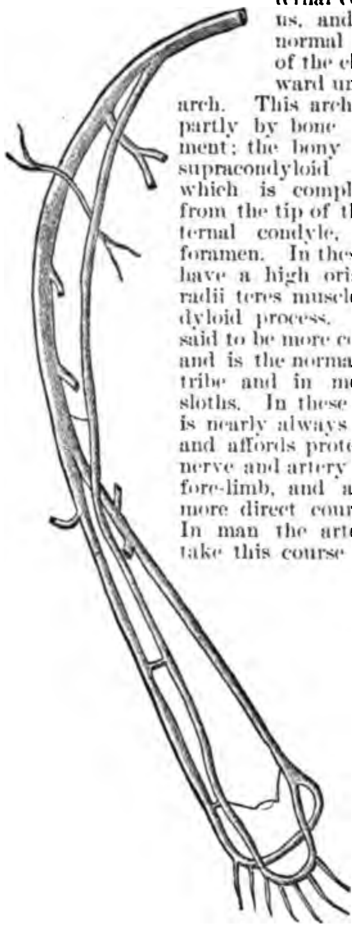

FIG. 296.—Example of an Aberrant Artery from Axillary, Going to Complete the Superficial Palmar Arch, Taking the Place in the Hand of the Superficial Volar.

Division: I have once seen the artery divide near its commencement into two branches which unite to form one trunk near the bend of the elbow, from which the ulnar and radial arteries are given off at the usual place (Fig. 297).

In 481 arms examined by R. Quain a high division was found 64 times, a low division (that is, below usual place) only once. Gruber, in 1,200 arms examined, found a high division in 82. In 500 arms examined by myself, I found a high division in only 27, and in one case the brachial divided below the pronator teres.

Adding to these the cases in which the division takes place in the axilla, in 481 arms examined by Quain two arteries existed in the arm in 94 cases, or 1 in about 5½. My statistics are quite different from the above, and I cannot account for the great diversity. The same class of people were examined, and they were of the same race. In 500 arms I found that two arteries existed in only 43 cases. This is made up as follows: division of axillary, 12; division of brachial, 27; aberrant arteries, 4—total, 43, or 1 in 11.6 cases. W. Gruber, in 1,200 arms, found a high division in 103, or 1 in 11.6, the same proportion exactly as in my own cases.

The point of division is in most cases in the upper third of the arm. It is also seen in the middle and lower thirds, but much less frequently. The artery which is given off thus prematurely is generally (three cases out of four) the radial; this vessel is most frequently to the ulnar side, and subsequently crosses to the radial. Next in frequency comes the ulnar, which often, in these cases, passes superficially down the forearm and gives off no branches, the interosseous coming from the radial (Fig. 298). In rare cases the interosseous is the branch having the high origin (Fig. 299), and still more rarely it is a vas aberrans.

Three branches have been seen in the arm, viz., the radial, the ulnar, and a vas aberrans.

The *position of the two branches* in the arm when a high division occurs is of surgical importance. They are usually in the ordinary position of the brachial trunk and lie close together, but the radial, as mentioned above, often arises from the inner side, and, after accompanying the large vessel for some distance, crosses over it at the bend of the elbow.

The *ulnar artery*, when having a high origin, may incline toward the internal condyle, this, however, occurs only when it nears the elbow. When there is a high division of the brachial the ulnar-interosseous branch may pass through the supracondyloid foramen mentioned above, and under a high origin of the pronator teres.

The *aberrant arteries*, which are given off occasionally, are long, slender arteries, which are derived from the brachial or axillary, and end by joining the radial most frequently and sometimes the ulnar and interosseous. They are loop lines, so to speak, and in cases of ligature of the brachial their occasional occurrence must be borne in mind by the surgeon (Fig. 300). The two arteries in the arm are in some instances connected together by anastomosing transverse branches. These branches may number two or three, or even four.

A *median artery* has been described as arising from the brachial and passing down over the muscles of the forearm and supplying the fingers to which is distributed the median nerve.

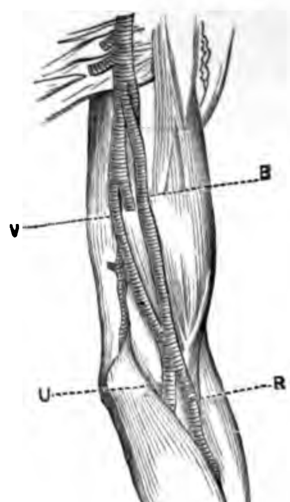

FIG. 297.—Brachial Dividing High up, Reuniting at Elbow, and Then Almost Immediately Dividing into the Radial and Ulnar. V, Vas aberrans. (After Reeves.)

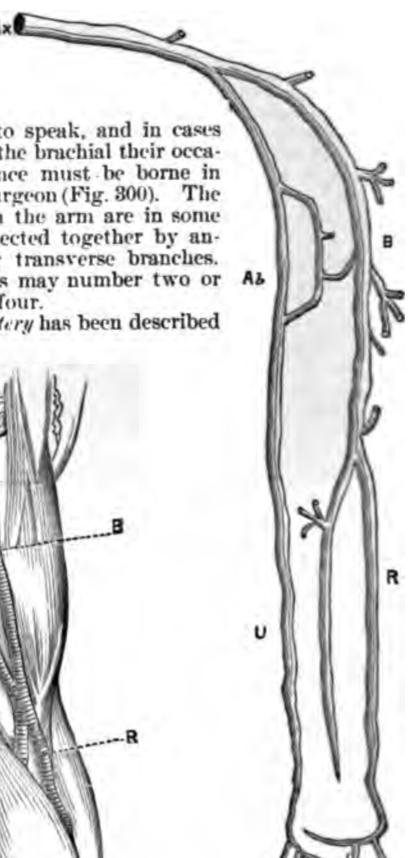

FIG. 298.—High Origin of the Ulnar Artery (U). Ab, aberrant artery; R, radial, giving off the interosseous arteries.

The brachial artery may in some part of its course (more frequently near the elbow) be covered by a muscular slip. The median nerve sometimes passes behind

instead of in front of the artery, especially in those cases in which the two heads embrace a common trunk from which the axillary branches are given off.

Superior Profunda.—This is occasionally derived from a trunk common to it and several of the axillary branches, as mentioned above. It not uncommonly arises with the circumflex, and occasionally gives off the inferior profunda.

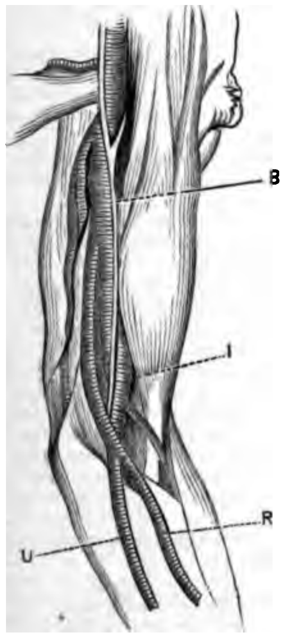

FIG. 299.—Anterior Interosseous (I) Given Off from the Brachial High up. (After Reeves.)

FIG. 300.—Aberrant Artery (3), separating from the brachial (1) at the middle of the arm, passing with the median nerve (d) through the internal intermuscular septum, and joining the regular ulnar (4) lower down. (Quain.)

Inferior Profunda.—This is often absent. It is frequently united with the superior profunda.

Anastomotica Magna.—Frequently of small size; its place is sometimes taken by the inferior profunda.

RADIAL ARTERY.—**Origin**: I have found that the radial has a high origin (Fig. 301) in 1 case in 21, but Quain reports the high origin to occur as often as 1 in 8. Gruber in 440 arms examined found the radial had a high origin in 26, or about 1 in 17 cases.

Course: The radial only very occasionally deviates from its usual course in the forearm. It has been found lying superficial to the fascia of the forearm, and the semilunar fascia of the biceps. It in rare cases courses down the forearm on the surface of the supinator longus instead of along its inner border. It not infrequently is superficial to the tendons of the extensor muscles of the thumb. It is occasionally joined by a vas aberrans. It may leave the front of the forearm near its middle, its place being taken by an enlarged superficial volar. This would cause a weak wrist pulse.

Size: It does not vary often in size. It is, however, sometimes much smaller than usual, its place being, to a considerable extent, taken by some other vessel, as the ulnar and anterior interosseous.

The radial has been described as absent by some anatomists. Quain never saw a case of absence of this artery, but such a case is described by Professor Otto, and I have seen one case.

Branches.—Radial recurrent: This vessel is sometimes of large size, or it may consist of several small branches. When the radial has a high origin the recurrent branch is given off from the ulnar-interosseous trunk.

Superficial volar: Very often of small size, so small that it terminates in the muscles of the thumb, and does not complete the superficial palmar arch. It is occasionally entirely absent. It may be of large size and furnish several digital branches (Fig. 302), and it may arise much higher than usual.

I once saw it arise as high as the middle of the forearm, and it was quite as large as the radial, from which it was derived; this is the normal arrangement in some monkeys. The *first dorsal interosseous* is, in some cases, of large size, and may supply several digits and end by completing the superficial arch.

The *carpal* and *dorsal interosseous* branches are often of very small size, their place being taken by the perforating arteries.

FIG. 301.—Dissection of Right Arm. Showing an example of high separation of the radial artery (3) from the brachial (2); a large median artery (10) is seen in forearm. (From Quain's "Anatomy," after Tiedemann.)

ULNAR ARTERY.—**Origin**: Quain found that this artery deviated from the usual origin in 1 case in 13, Gruber 1 in 29, myself 1 in 37.

Where the origin of the ulnar is unusual, it most commonly arises from the brachial in the arm, and less commonly from the axillary. In one case out of five hundred I found it coming off from the brachial below the pronator radii teres. In this case there was, of course, a low division of the brachial.

Course: In the forearm this artery is much more subject to variation than the radial. When it has a high origin it nearly always courses down the forearm superficial to the muscles, but beneath the fascia; but cases occasionally occur in which it is immediately beneath the skin and superficial to the fascia (Fig. 303). When the ulnar is superficial, it, as a rule, gives off no branches in the forearm, these being given off from the radial—interosseous trunk—or the interosseous itself, which is invariably given off from the radial. The ulnar, in rare cases, has this superficial course when it arises in its usual situation.

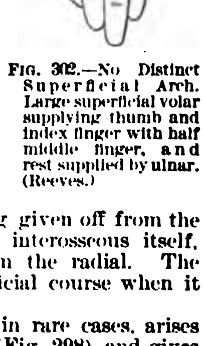

FIG. 302.—No Distinct Superficial Arch. Large superficial volar supplying thumb and index finger with half middle finger, and rest supplied by ulnar. (Reeves.)

Interosseous Artery.—This artery, in rare cases, arises from the axillary or brachial artery (Fig. 298), and gives off the recurrent radial and ulnar arteries. The anterior

and posterior interosseous may arise separately from the ulnar.

Median Artery (Fig. 304).—This branch, which accompanies the median nerve, is ordinarily of small size, but occasionally it is developed into quite an important vessel. It is usually derived from the anterior interosseous, but sometimes from the ulnar, and, in rare cases, it has been found coming from the axillary or the brachial. It accompanies the median nerve and reaches the hand beneath the annular ligament, but, according to Tiedemann, sometimes passes over the ligament. It may complete the palmar arch, or be distributed as digital branches to certain of the fingers, generally those supplied by the median nerve, which it accompanies. In the cases which I have observed, the latter arrangement was the more frequent. I have occasionally seen this artery pierce the median nerve.

FIG. 303.—Abnormal Superficial Ulnar Artery (3, 3'), Rising Higher than Usual from the Brachial. (Quain's "Anatomy," after R. Quain.)

FIG. 304. Dissection of Left Arm, Showing an enlarged median artery (5) which replaces the radial (2) and ulnar (3) arteries in the supply of the palmar digital arteries to half the fingers. (From Quain's "Anatomy," after Tiedemann.)

ARTERIES OF THE HAND.—The arteries of the hand are subject to many variations.

The superficial palmar arch is sometimes entirely wanting. It has been occasionally seen double. In the majority of cases the superficial volar branch does not complete the arch, but it is completed often by a large branch from the radial, which emerges between the thumb and forefinger, and I have sometimes seen it completed by a large branch from the radial, which, after coursing over the back of the hand, emerges on the palm between the index and middle fingers. The arch is also often completed by a transverse branch, which comes from the muscles of the thumb and is derived from the princeps pollicis or radialis indicis branch of the radial (Fig. 305). A median artery may complete the arch (Fig. 306), or it may go to the digits on the radial side, and the ulnar to the digits on the ulnar side, and no regular arch be formed. The superficial volar sometimes has this arrangement (Fig. 306).

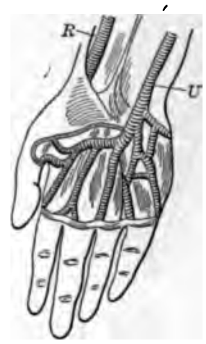

FIG. 305.—Superficial Arch Formed Entirely by the Ulnar and Joining the Princeps Pollicis Artery. (Reeves.)

The superficial arch may be very small and some of the digital branches be wanting, or it may be very large, supplying all the digital branches, both superficial and deep.

The deep arch is occasionally formed by the ulnar. It is sometimes so deficient that the digital arteries are derived from the superficial arch. A large metacarpal branch on the back of the hand may give off the digital branches.

ABDOMINAL AORTA.—According to R. Quain, in ten out of every thirteen bodies the division of the great artery took place within half an inch above or below the level of the iliac crest. Eckhard, Boinet, and Cruveilhier record cases of division as high up as the second lumbar. Two cases are on record (Quain, tenth ed.) of a large pulmonary branch which arose below the diaphragm, passed through the œsophageal opening, and divided into two branches which supplied the lungs near their bases.

CŒLIAC AXIS.—The branches of this artery may arise separately from the aorta. The phrenic arteries may be given off from it, and it may be connected with the superior mesenteric.

RENAL ARTERIES.—Now that the operation of nephrectomy has become so common, the variations of these arteries have been rendered important surgically. Professor Macalister has reported (*Journ. Anat. and Phys.*, vol. xvii.) most of the anomalies of the renal artery.

The renal artery may be replaced by two, three, four, and even six branches. The origin of these arteries is very various; they are usually derived from the aorta, and are separated, at their origin, by a larger or smaller interval; the lowest may arise quite near the bifurcation of the aorta, and the highest just below the cœliac axis. In some rare instances the renal artery has been described as arising from the common iliac, internal iliac, and middle sacral. The right and left renal arteries have been found coming from a common trunk; they may arise from the anterior or lateral part of the aorta. The suprarenal frequently gives off an upper renal, and it less frequently is derived from the upper lumbar, hepatic, and right colic. Frequently when the renal arteries come off from the aorta low down or the iliacs, the kidney on that side is misplaced; it is situated lower down than usual, opposite the bifurcation of the aorta and even between the two common iliacs. In such cases the hilum is usually placed on the anterior surface.

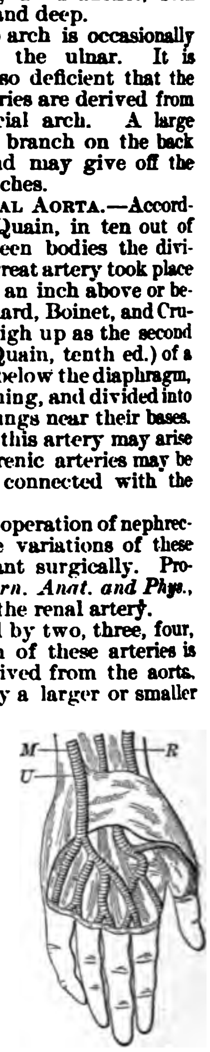

FIG. 306.—Large Median Artery (M), Taking the Place of the Radial in the Formation of the Superficial Arch and Giving Off Outer Digitals. (Reeves.)

INFERIOR MESENTERIC.—It may be absent, its branches being given off from the superior mesenteric.

The branches of the renal artery, instead of entering the hilum, may penetrate the kidney at its upper or lower end. It is not uncommon to see the normal artery entering the hilum, and two or three supernumerary branches piercing the upper and lower end of the gland. In two subjects I found that the kidney was supplied by

two arteries arising from the aorta at some distance apart, one going to the extreme upper end, and the other to the extreme lower end of the kidney; no artery entered the hilum (Fig. 307). The vein and duct were normal. This variation I once met with while performing nephrectomy on the dead body. R. Quain met with a case of absence of the renal artery on one side. Multiple renal arteries occur normally in fishes, lizards, snakes, crocodiles, and birds, and in man are due to a persistent early fetal condition.

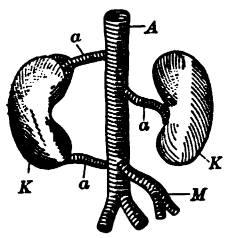

FIG. 307.—Abnormal Right Renal Arteries. An artery distributed to each extremity of the kidney, but none entering the hilum.

SPERMATIC ARTERY.—Sometimes double, not infrequently derived from the renal. Three spermatic arteries have been seen.

COMMON ILIAC ARTERIES.—The place of origin of these arteries depends on the place of division of the abdominal aorta. This may be as high as the upper border of the third, or as low as the lower border of the fifth lumbar vertebra. In three out of four cases the aorta divides opposite the lower border of the fourth lumbar.

The common iliac arteries vary considerably in length. I once saw them only 1.8 cm. (three-fourths inch) long in a negress, and, in another case, 2.5 cm. (one inch). In the large majority of cases, according to R. Quain, the length varies from 3.7 cm. (one inch and a half) to 7.5 cm. (three inches). The greatest length is about 10 cm. (four and a half inches).

The right and left common iliacs differ in length very often, the right, owing to the aorta dividing to the left side of the spinal column, being often the longer; but the left may be the longer, and in about one-third of the cases they are of equal length (R. Quain).

When the left is longer than or equal to the right, it is owing to the left artery descending to a lower level than the right. The artery has been seen dividing into internal and external iliacs as low down as the iliac fossa.

The common iliac on one side has been reported absent by Cruveilhier and Walsham. In this case the aorta divided into three branches, two on the right (external and internal iliac), as is seen in birds, and one on the left (common iliac). Surgically, these variations are of great interest.

INTERNAL ILIAC.—The place of division of this vessel varies considerably; it may divide as low as the margin of the sacro-sciatic foramen and as high as the upper margin of the sacrum. The point of division is of importance surgically; when the trunk is short it is more deeply placed in the back part of the pelvis, but when it is of some length, then a part of the artery is likely to lie above the pelvic cavity, and therefore would be much more easily reached by the surgeon (R. Quain). It has been found as short as 1.2 cm. (half an inch), and as long as 8.2 cm. (three and a half inches).

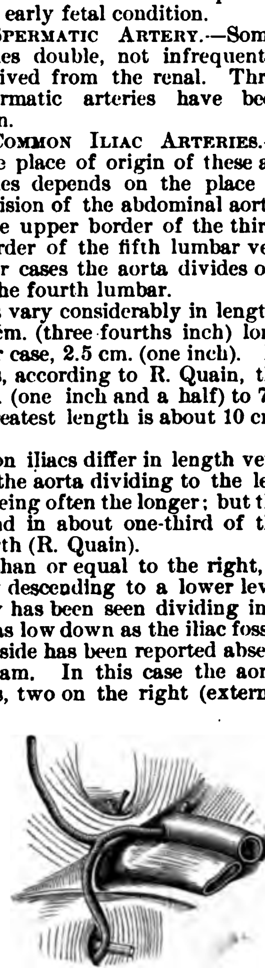

FIG. 308.—Obturator Given Off from the Internal Epigastric, and Passing to the Inside of the Crural Ring to Reach the Obturator Foramen. (After Gray.)

The branches are given off from this artery very variously. In many cases there is no division into anterior and posterior trunks. The artery occasionally gives off one, and sometimes two branches before it divides. The variations of most of the branches of this artery, being of no surgical importance, will not be discussed here.

OBTURATOR.—According to R. Quain, the obturator artery arises from the epigastric in 1 case in 3.5. His conclusions are derived from observations in 361 cases. I have observed 500 cases (250 subjects), and have found this abnormal arrangement much less frequently than Quain. I have found the obturator coming from the epigastric in only 1 case in 9 (55 in 500). Quain found the obturator derived from the external iliac in 6 cases out of 361. I found it only 3 times in 500 cases. Quain found the epigastric giving off the obturator 23 times on both sides. I found this arrangement 11 times.

When the obturator arises from the epigastric or external iliac, it reaches the thyroid foramen by arching either to the inner or to the outer side of the femoral ring. If it arches to the inner side of the femoral ring, along the edge of Gimbernat's ligament, then, in case of strangulated hernia requiring operation, it would be in great danger of being wounded (Fig. 308); in fact, this accident has happened more than once.

FIG. 309.—The Same, Passing to the Outside of the Ring. (After Gray.)

In only 9 out of the 58 cases in which the obturator proceeded from the epigastric and external iliac did I see the artery going to the inner side of the femoral ring. In the remaining 49 cases it either crossed it, in a few cases, or held a position well to the outer side in the majority (Fig. 309), so that in only about 1 case in 50 is there danger of wounding the obturator in the operation for strangulated hernia. The explanation of the origin of the obturator from the epigastric is simple enough. Normally, we have the pubic branch of the obturator anastomosing with the pubic branch of the epigastric; these vessels become enlarged, and the proper obturator branch of the internal iliac either remains undeveloped or becomes obliterated.

In four cases I have seen the obturator, epigastric, and internal circumflex arise together from the external iliac, and once these same arteries were seen to arise by a common trunk from the common femoral 2 cm. below Poupart's ligament. In one case the epigastric and obturator arose together from the femoral, a little below Poupart's ligament. In some cases, in which the obturator arises from the epigastric, there is a small branch, representing the obturator, derived from the internal iliac.

Internal Pudic Artery.—This vessel is occasionally of small size, and fails to supply all the usual branches; in such an event these are given off from an accessory pudic. The branches furnished by the accessory artery are usually those branches which go to the cavernous body and dorsum of the penis, the pudic itself ending as the artery of the bulb. In a few instances the pudic ends as the superficial perineal, the other branches coming from the accessory vessel.

The accessory pudic is, as a rule, given off from the deep pudic within the pelvis; it then passes alongside the bladder and prostate, and, after piercing the triangular ligament, supplies the dorsum of the penis and the cavernous body, and, perhaps, the bulb. It may be given off from the obturator in the pelvis, or from the epigastric.

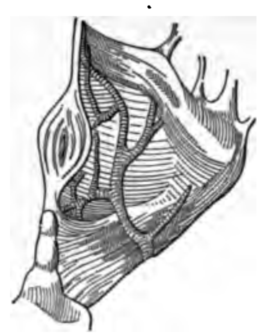

FIG. 310.—Abnormal Internal Pudic Artery, Which Has a Course Midway between the Ischial Tuberosity and the Coccyx. (After Henle.)

The pudic artery has been seen passing up to the perineum midway between the tuberosity of the ischium and the coccyx, and ending as the superficial perineal and artery of the bulb (Fig. 310).

Artery of the Bulb.—Is sometimes of large size, placed farther back than usual, and ascends obliquely to the

bulb; in such a case it would necessarily be wounded in the operation of lithotomy. It may arise from the accessory pudic; when this happens it would be placed well in front of the usual incision for lithotomy.

The *dorsal artery of the penis* has in some cases been seen to arise from the obturator artery near the thyroid foramen, from the external pudic of the femoral, and from the deep femoral. In the first case it would be in danger of being wounded in lithotomy. The two arteries

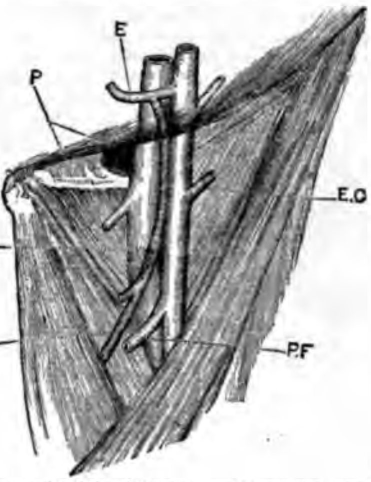

Fig. 311.—Abnormal Origin of the Internal Circumflex Artery (I): E, epigastric artery; PF, profunda femoris.

of the penis sometimes unite to form a single trunk, or are united by transverse branches. Mr. Spence has described a large prostatic artery which gained the perineal surface of the prostate without dividing into minute branches. Wounds of the prostatic arteries have led to fatal hemorrhage in cases of lateral lithotomy.

The *sciatic artery* is sometimes replaced by a branch from the gluteal. In a few cases this artery has been seen of large size, taking the place of the femoral (see under Variations of Femoral). There is sometimes a large comes nervi ischiatici artery. The gluteal artery has been reported as absent (Roberts), its place being taken by a large branch from the femoral, passing outward and backward to the gluteal region.

External Iliac Arteries.—The length of these arteries varies according to the point at which the common iliacs bifurcate; they usually measure 7.50 cm. (three inches) to 10 cm. (four inches) in length. In those rare cases in which the main artery of the limb is a continuation of the sciatic, it is much reduced in size.

Epigastric Artery.—May arise at a higher point than usual. R. Quain reports it in one case 6.4 cm. (two and a half inches) above Poupart's ligament. It arises from the femoral in about one case in twenty. The usual place of origin is close to or opposite Poupart's ligament. It may, in rare cases, arise from the deep femoral.

The origin of the obturator from the epigastric has already been noticed. In a few cases the epigastric has been seen coming from the obturator when that vessel is a branch of the internal iliac.

I have, in four instances, seen the epigastric arise in common with the internal circumflex artery of the deep femoral. In three of the cases the common stem arose from the femoral 2 cm. below Poupart's ligament; in the fourth, 2 cm. above the ligament. In the last-named case the internal circumflex passed beneath Poupart's ligament in the same compartment of the femoral sheath as the artery, and continued down the thigh about 5 cm., lying between the artery and vein; it ended, after giving off a large branch to the adductor muscles, as the internal circumflex proper (Fig. 311). A similar anomaly has been observed by Mr. A. Thompson (*Journal Anat. and Phys.*, April, 1883), but in the cases described by him the artery passed internal to the femoral vein, and would, he thinks, have been wounded in the operation for relieving strangulated femoral hernia. A similar arrangement of vessels exists normally in the American black bear. I have met with four cases in which the obturator, epigastric, and internal circumflex arose by a common stem, two below Poupart's ligament and two above.

Circumflex Iliac Artery.—The origin of this artery is sometimes from the femoral. It is occasionally double.

Femoral Artery.—The femoral artery has, in some rare cases, been found of small size, and terminating near the knee joint. When such a condition exists, the main artery of the limb is furnished by a branch from the internal iliac, generally the sciatic (Fig. 312), which is much enlarged, and accompanies the sciatic nerve to the popliteal space, whence the course of the artery is the same as if the distribution had been normal. This is the usual arrangement in birds.

Cases have been reported in which the femoral divided into two portions, which united below to form again a single vessel. Sir Charles Bell, when ligaturing the femoral for popliteal aneurism, met with this anomaly.

Fig. 312.—Posterior View of the Right Thigh. The ischiatic artery much enlarged, accompanying the sciatic nerve, and taking the place of the femoral artery. (After Dubreuil.)

Fig. 313.—Bell's Case of Double Femoral Artery. Showing ligature of one of the trunks and the aneurismal tumor below. (After Bell, from *London Medical Gazette*.)

Though the ligation of the femoral did not arrest the pulsation in the aneurism, the cause was not recognized till after the death of the patient, when it was found that the femoral was double, and only one of its divisions had been ligatured (London *Med. and Phys. Jour.*, vol. lvi., 1826). (See Fig. 313.) Tiedemann, Houston, Dubreuil, Tyrrell, and Quain also report cases. Mr. H. A. Kelly (*American Journal of the Medical Sciences*, January, 1882) reports three cases (one of which is doubtful), met with in the dissecting rooms in Philadelphia. In two of these cases the artery divided below the profunda, and reunited just above the opening in the adductor magnus.

The division has been seen above the origin of the profunda.

The two femorals, when this arrangement occurs, run down the thigh, side by side, in separate fibrous sheaths, so that in cutting down on one the other would not be seen.

I have occasionally seen, in cases of high origin of the profunda, the latter artery quite as large as the superficial femoral, and running down the thigh parallel to it, beyond the apex of Scarpa's triangle. In such a case it would be difficult, in the living, to distinguish between the vessels, should ligature of the femoral be necessary. As a rule, the profunda lies to the outer side. The appearance of the above-described condition in Scarpa's triangle is very similar to those cases figured as double femoral, and I imagine that the cases of double femoral reported as seen in amputating the thigh are only cases of large profunda arteries, especially as the disposition of the vessels below the amputated point is not described.

The *profunda*, or deep femoral artery, may be given off from the inner side of the main trunk, or even in some cases from the back part of the vessel. It may arise above Poupart's ligament, or as much as 10 cm. (four inches) below it. It not uncommonly arises 1.2 cm. (half an inch) below the ligament. When it is given off low down, one or both circumflex arteries arise from the femoral. The deep femoral has been occasionally altogether wanting, its branches arising separately from the main artery.

The *external circumflex artery* not infrequently arises directly from the common femoral. It may be represented by two branches, and even three, which arise from the femoral or profunda—I have seen it arise in common with the internal circumflex. The *internal circumflex artery* also frequently arises directly from the femoral. It occasionally arises in common with the deep epigastric, and passes down to the thigh in the same sheath as the femoral vessel. This variety I have described under the Epigastric. It may arise with the epigastric from the femoral artery before the profunda is given off, and in some cases might be injured in the operation for strangulated femoral hernia. I have twice seen it arise with the obturator and epigastric from a common stem.

Unusual branches are, in rare cases, given off from the femoral. I once saw the dorsal artery of the penis given off from the common femoral, cross the thigh at right angles, and reach the dorsum of the penis by piercing the deeper scrotal tissue.

A large saphenous artery has been found which accompanied the great saphenous vein. It may arise above or below the profunda, course down the thigh between the adductor magnus and internal vastus, and pierce the deep fascia of the thigh on the inner side of the knee joint, where it reaches the internal saphenous vein and accompanies it to the internal malleolus. This arrangement is the normal one in the rabbit and in some other mammals.

I once saw this branch, after reaching the inner side of the knee, wind round to the front of the joint, below the patella, and divide into a cutaneous branch and a branch which pierced the ligamentum patellæ to supply the interior of the joint.

POPLITEAL ARTERY.—This artery is not subject to many variations. The chief deviation from the normal disposition consists in a high division of its terminal branches. I saw this only twice in 250 subjects; in both, the artery divided immediately above the upper edge of the posterior ligament of the knee joint. In 227 subjects Quain found a high division in 10. Portal reports a case of low division of the popliteal, the artery dividing about the middle of the leg into anterior and posterior tibial. In some cases of high division, the peroneal artery arises from the anterior tibial; this was the arrangement in one of my cases. The artery and vein, usually so constant in their relation, may, in rare cases, change places. When there is a third head to the gastrocnemius muscle it usually passes between the artery and the vein. Ward Collins has seen the popliteal artery dividing in the upper part of the popliteal space into two branches which united again below after a separate course of two inches.

Cases are reported (Otto) of branches from the popliteal proceeding upward along the semimembranosus muscle, and ending in one of the perforating arteries of the profunda. Also an aberrant artery is described as being given off above the knee joint, and joining the popliteal before its division (Hyrtl). A small saphenous artery has been seen which accompanies the short saphenous vein behind the external malleolus and anastomoses with one of the tarsal branches (Hyrtl). The azygos artery may be given off from one of the articular arteries. I once saw a common trunk give off the two superior articular arteries and the azygos. One or other of the articular branches may be absent, their place being supplied by an enlargement of the remaining arteries.

Posterior Tibial.—In cases of high division of the popliteal the tibial is larger than usual. It may be increased or diminished in size. When increased, it partly takes the place of the peroneal or anterior tibial, and when diminished, it may be reinforced by transverse branches from the peroneal near the ankle. The posterior tibial may be of very small size and end near the middle of the leg, its place being taken by a large peroneal artery which furnishes the plantar arteries. In a lesser degree of diminution of the posterior tibial, the anterior tibial, or rather its dorsalis pedis branch, furnishes the arteries which form the plantar arch and its branches. In these cases the external plantar artery ends near the accessorius muscle. I have several times seen a muscular slip (flexor accessorius), which arose from the lower end of the fibula, or more commonly from the tibia, cross the tibial vessels behind the internal malleolus. The nerve is occasionally placed to the inner side of the artery, at the lower part of the leg.

Peroneal Artery.—This artery, as described above, may take the place of the posterior tibial, or it may be of small size, and its place be supplied by a branch of the posterior tibial. The anterior peroneal branch may be of large size, and may take the place of the lower part of the anterior tibial, furnishing the arteries supplying the dorsum of the foot.

In cases of high division of the popliteal, the peroneal artery generally arises from the anterior tibial. It also arises in the same way, occasionally, when no high division takes place. I have seen it furnish a large internal calcanean branch as well as an external. An accessory peroneal sometimes exists.

The *internal plantar artery* is sometimes of very small size, ending in the flexor brevis pollicis muscle, or it may be of large size, and furnish digital branches to the great and second toes.

The *external plantar* is occasionally very small, ending in the accessorius muscle; when such a condition exists the dorsalis pedis artery furnishes the deep plantar arch and digital branches. I have several times seen this anomaly. The artery is occasionally of large size, and partly takes the place of the dorsalis pedis branch of the anterior tibial. The digital arteries of two toes, generally the second and third, not infrequently come from a common stem. The deep arch is, in rare cases, double.

Anterior Tibial Artery.—In some cases this artery is given off from the posterior tibial in the middle of the leg. When there is a high division of the popliteal it may give off the peroneal, and may pass beneath the popliteus muscle. In the leg it may be subcutaneous, its pulsations being easily felt under the skin. Velpeau reports a case in which this artery did not pierce the interosseous membrane, but passed to the front of the leg round the fibula with the musculo-cutaneous nerve. It may be altogether wanting, its place being supplied by perforating branches from the posterior tibial, or it may end in the muscles about the middle of the leg. When there is such a distribution the deficiency is made up by an enlarged anterior peroneal or plantar artery.. It not infrequently fails to furnish digital branches, which, in

this event, come from the plantar arteries. The artery may be of larger size than usual, and may take the place of the peroneal artery in some cases, and of the plantar branches of the posterior tibial in others; the dorsalis pedis branch being of very large size, as mentioned in the description of the varieties of the posterior tibial. The dorsalis pedis artery sometimes ends in the neighborhood of the cuneiform bone. The anterior tibial, in some rare cases, gives off an anterior tibial recurrent to the knee joint. *Francis J. Shepherd.*

ARTERIES, COMPRESSION OF. — INDICATIONS. — Compression of arteries for the arrest and prevention of hemorrhage and for the cure of aneurism is a very old procedure, and one which, although in many instances superseded by ligation, made safe by the introduction of antiseptic surgery, is still employed to a considerable extent, particularly in the prevention of hemorrhage. Compression of the carotids, thereby lessening the blood supply to the brain, has been recommended and practised at different periods in the treatment of epileptic convulsions, maniacal excitement, congestive headache, and for the purpose of producing sleep. Dr. Corning, of New York, in 1882, strongly urged the advantages of this procedure and devised a special instrument for the compression of the carotids.

MEANS.—Compression is accomplished either by means of the hand or by some mechanical device. Digital compression may be either direct or indirect, that is, in the wound or over the vessel of supply, and may be employed for the immediate arrest of existing hemorrhage or for the prevention of hemorrhage during an operation. This means is occasionally still used in the treatment of aneurism, but has largely been superseded by the ligature, and by the combined use of gold or silver wire and electricity. For the instant arrest of bleeding nothing is more readily and satisfactorily employed than the fingers, placed either directly in the wound or over the arterial trunk supplying it. The greatest disadvantage of the method is that it is impossible to keep it up for a great length of time without the help of a number of intelligent assistants. There are two ways of applying digital compression, one by pressing the vessel between the fingers and a bone, the other by compressing it between the forefinger and the thumb. The former method is more satisfactory, because it can be kept up for a much longer period of time. When a change of hands is made the fresh hand should always be placed above the point of former compression before the first hand is removed. Digital compression can much more readily be employed when a wound has been made, thus exposing the vessel, than when it is attempted with considerable tissue intervening between the finger and the vessel, as, for instance, in compression of the abdominal aorta.

Innumerable forms of compression apparatus have been invented for compressing blood-vessels, one of the oldest and most universally used being the tourniquet of

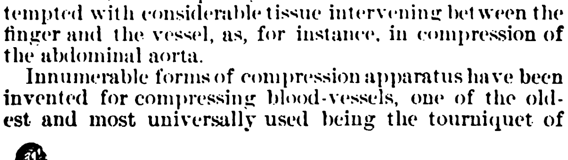

FIG. 314.—Esmarch's Elastic Compressor.

Petit (Fig. 120), which consists of two metal plates, connected by a spiral screw, whereby they may be separated, and a strap which buckles around the limb. In the use of this tourniquet many surgeons apply a roller bandage over the vessel to be compressed and buckle the strap over this. The separation of the plates by the screw tightens the strap and increases the pressure. In order to prevent the strap from cutting the skin it is well to apply first a turn or two of muslin bandage about the part. In an emergency, when a tourniquet cannot be had, a fillet may be employed by passing a handkerchief or piece of cloth or cord about the limb and then tightening it by twisting it with a piece of wooden stick. The most generally used means of compression to-day is the Esmarch bandage and tube (Fig. 314). The bandage is an ordinary rubber roller applied from the tip of the extremity up to the point where it is desired to place the tube, and its object is the saving of the blood in the extremity, in case of amputation, and the freeing of the limb of blood when any operation is to be done upon it. The tube is of rubber, flat, and about one inch wide. This is passed tightly about the limb and fastened by a hook at one end of the tube and a chain at the other. Certain precautions must be observed in the use of this form of compression. One is to move the part as little as possible after the tube is applied, as tearing of the tightly bound down muscles may occur, and another is to see that each turn of the bandage and tube overlaps the preceding, else pinching of the skin occurs. When a limb is diseased, compression with the bandage is not to be made over the diseased area, but it is to be applied above and below it, or else it is not to be used at all, but the limb is simply to be elevated for a time, after which the tube alone is to be used. This method of elastic constriction has the great advantages of simplicity and cleanliness over other forms of mechanical compression.

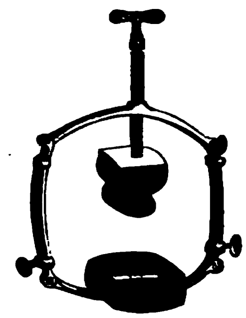

FIG. 315.—Skey's Arterial Compressor.

Other forms of compression apparatus are so constructed that the pressure is exerted over the main artery without constricting the surrounding tissue. These forms are specially advantageous in the treatment of aneurism, for they are much less likely to cause gangrene, which is so apt to follow the prolonged use of the two forms of compression above described. Esmarch's elastic compressorium for the aorta and Skey's compressor (Fig. 315) illustrate this point.

About ten years ago Dr. Wyeth, of New York, introduced a new method of compressing the vessels of the thigh in hip-joint amputation. This method (see Figs. 191, 192, on page 265), which is a combination of the older methods of Trendelenburg and Dieffenbach, consists in passing through the muscular tissue and skin above the point of amputation two long steel mattress needles, and then applying above them the constricting band of Esmarch. This method is also used in amputation at the shoulder joint and has done a great deal to reduce the mortality of these operations, in which the loss of blood had formerly been so great. It must not be forgotten that all forms of compression, if kept up for a great length of time or if the pressure is too great, may be productive of destruction of tissue at the point of application or of gangrene in parts below. Also it must be remembered that after circular constriction of an extremity reactionary hemorrhage may occur, and hence it is necessary to tie all bleeding points before closure of the wound.

SPECIAL ARTERIES.—The *aorta* cannot be compressed until it has passed through the diaphragm into the abdomen, and then only with difficulty, unless the abdomen be opened. Compression of the abdominal aorta is resorted to as a means of preventing severe hemorrhage from its distributing branches or for the purpose of temporarily arresting the circulation in them: for example, in a hip-joint amputation, or in an attempt to cure an aneurism. It can be satisfactorily accomplished without abdominal section in thin persons, but in those with thick abdominal walls it is very difficult of accomplishment. As to the precise mode of effecting the desired pressure, one may employ an Esmarch's elastic compressor or that of Skey,

both of which are shown in the illustrations (Figs. 314, 315), or the hand of an assistant may be employed. All of these methods are open to objections: they may cause an injury to the overlying intestine—and this is more likely to happen when an apparatus is used—or the compression may prove to be inefficient, as when the instrument is not properly applied, or when it slips, or when the assistant's hand moves to one side of the artery. The usual position for the compression pad or the hand is just below the umbilicus and a little to the left: but the pulsation of the vessel must be definitely felt before compression is applied, and after the application of compression no operation should be done until all pulsation has ceased in vessels below. There will be less danger of injuring the intestinal canal if it be first emptied by means of a cathartic or an enema; and before applying the pad, the bowels should be pushed to the right side of the abdomen by rolling the patient on that side. When the abdomen is opened compression of the aorta is rendered easier and safer; it may be accomplished with the

FIG. 316.—Compression of the Aorta. (Dr. W. W. Keen.) Right hand closed, a little to the left of the median line: knuckles of index finger just touching the upper border of the umbilicus; left hand feels patient's pulse (femoral) at brim of pelvis.

fingers or with a specially devised clamp consisting of two blades, one of which fits into the other somewhat after the style of a lithotrite. Great care should be exercised in the use of such an instrument or an injury may be done to the vessel itself or its neighbors.

The *common iliac* may be compressed through the abdominal wall, through the rectum, or through an incision in the abdominal wall. The last method, which enables one to use the fingers, is by far the most satisfactory of the three and the only one that has been practised with anything like good results. It has become now one of the recognized means of preventing hemorrhage in hip-joint amputation, particularly in those cases in which, because of diseased anterior flap, the Wyeth pins cannot be used. Dr. Charles McBurney first employed this method of preventing hemorrhage in 1894. Experience has shown that the common iliac can very readily be compressed with the fingers in the abdominal cavity without the exertion of much force and without increasing the dangers of the operation. Compression through the rectum by means of Davy's lever is not so safe or so satisfactory as are the other methods.

External Iliac.—This vessel can be compressed with the fingers or with an instrument placed just above Poupart's ligament, midway between the symphysis pubis and the anterior superior spine of the ilium.

Femoral.—The course of this vessel is covered by a line drawn from the point midway between the symphysis pubis and the anterior superior spine of the ilium to the adductor tubercle on the inner condyle of the femur, and can be compressed by the fingers or by the tourniquet anywhere throughout its course, the force being exerted toward the bone.

FIG. 317.—Compression of the Brachial.

The *popliteal* occupies the middle of the popliteal space; it can best be compressed against the femur in the upper part of its course.

The *posterior tibial* can readily be compressed by the finger as it passes midway between the internal malleolus and the point of the heel.

The *anterior tibial* lies between the tendons of the tibialis anticus and the extensor longus hallucis, and can best be compressed after it becomes the dorsalis pedis and passes under the annular ligament.

The *subclavian* can only be compressed, unless exposed by incision, in its last one-third, where it crosses the first rib. Pressure should be made with the thumb in the angle formed by the posterior border of the sterno-cleido-mastoid and the clavicle, and should be directed downward, backward, and inward against the rib. The tip of the shoulder should be depressed.

Axillary.—Compression of this vessel can be made only in the last part of its course, and is accomplished by making pressure from within outward against the upper part of the humerus.

The *brachial* artery can very readily be compressed against the shaft of the humerus, the inner edge of the biceps being the guide to its situation.

FIG. 318.—Compression of the Femoral.

The *radial* can be compressed against the anterior surface of the lower end of the radius between the tendons of the supinator longus and the flexor carpi radialis.

The *ulnar* artery can be compressed against the anterior surface of the ulna between the flexor carpi ulnaris and the flexor sublimis digitorum.

The *common carotid* and the *external carotid* can be compressed with the fingers or by means of one of the instruments specially devised for the purpose. The anterior border of the sterno-cleido-mastoid is the guide to the vessels, and the pressure should be directed backward and inward.

The *facial* can be compressed with ease as it passes over the lower jaw just in front of the masseter muscle.

The *temporal* may be controlled by making pressure on the zygomatic process just in front of the tragus.

The *labial* artery may be controlled by compressing the lips between the finger and thumb.

John H. Gibbon.

ARTERIES, HEALING OF, AFTER LIGATURE, ACUPRESSURE, TORSION, AND SUTURE.—Although the introduction of the ligature is commonly ascribed to Paré, there is sufficient evidence to show that it was employed by surgeons in the earliest historic times. No mention is made of the ligature by Hippocrates, but the ancients used not only styptics and the actual cautery, but also ligature and torsion. It is highly probable that the Alexandrians were familiar with the use of the ligature three centuries before the Christian era, for Celsus (born 30 B.C.) speaks of it as a well-known fact and recommends its use. Rufus of Ephesus, a century later, makes the following mention of torsion: "Vas immissa volsella extendemus et moderate circumflectemus: at ubi ne sic quidem cessaverit [hæmorrhagia] vinculo constringemus." Archigenes and Galen both mention tying vessels for the purpose of stopping hemorrhage; the name of Antyllus also bears testimony to the skill of Roman surgeons, and in the Museum at Naples there may be seen a forceps, with sliding attachment, evidently intended to use with the ligature. We find the ligature of arteries mentioned again in the seventh century by Paulus of Ægina, whose teachings were still preserved by the Italians in the sixteenth century. In Lanfranchi's "Surgery" (1295) occurs the following passage: "Oportet te nunc aut venam ligare et ipsam de loco extrahere, et caput venæ vel arteriæ contorquere, aut ferro candente sanguinem sistere."

It is uncertain, however, whether ligatures were employed on large vessels before Paré's time. To this great surgeon is due the credit not only of fully appreciating the value of this mode of hæmostasis, but of making it a universally applicable method. At this period, the middle of the sixteenth century, the imperfect knowledge of the anatomy and physiology of the circulation prevented a due appreciation of the advantages of the ligature, and even Guillemeau, who was the champion of his friend and teacher, confined the use of the ligature to primary amputations. Although Wiseman in England, Fabricius Hildanus in Germany, Fallopius, and others favored the ligature, they were but isolated examples, and at the opening of the eighteenth century the actual cautery was still the customary method of arresting hemorrhage at the Hotel-Dieu.

The contrast between the two methods at that time was not indeed as great as it would seem to-day. A glance at Paré's plates shows the forceps as an instrument of rude pattern and clumsy make; no attempt was made to isolate the vessel; veins, nerves, and arteries being included in one knot. No wonder that surgeons had a "horrid apprehension of compressing the nerves," and that Petit, with whom modern investigation on the healing of arteries may be said to have begun, actually proposed compression as a substitute for the ligature. It was he who first called attention to the agency of the thrombus in checking bleeding, the blood around the end of the vessel being termed the *couvercle*, and that found within the lumen the *bouchon*. The retraction and contraction of the vessel were soon recognized by Morand, who also called attention to the rupture of the inner walls by the ligature. Pouteau, of Lyons, thought that the swelling of the tissues surrounding the mouth of the vessel was as important a factor as any other in bringing about the arrest of hemorrhage, and he devised what has since been called the mediate ligature. This was, however, a return to obsolete methods, and a protest was soon raised against its brutality. In England, Gooch and Kirkland dwelt strongly upon the action of the vessel wall, and the former showed that the sides even became adherent for some distance, the vessel shrinking into a cord. White even thought that the clot was injurious and should be removed; John Bell, on the other hand, thought that the extravasated blood in the tissues compressed the vessel, which subsequently receded by adhesive inflammation. Hunter gave a great impetus to the study of the process of repair in arteries through his views on healing by first intention. He first enunciated a theory, which has since led to much discussion, concerning the organization of the thrombus and its vascularization, which he likened to the changes seen in the embryo of the chick; but he also believed in a direct adhesion of the arterial walls. It was due to him, also, that the subsequent establishment of a collateral circulation was recognized. To Jones, however, has been pretty generally accorded the credit of producing the classical work upon this subject. By a large and varied series of experiments on animals he was able to give a complete account of the macroscopical appearances showing injuries to arteries, which account, in the main, holds good to-day. He found that when a large artery was divided it retracted into its sheath, and contracted slightly at its extremity (a coagulum forming within the sheath and external to the vessel, and appearing like a continuation of the artery); and that later a slender and conical coagulum formed within the vessel, being only partially adherent to its walls. Permanent occlusion, he says, is effected by the inflammation of the wall, the vasa vasorum pouring out lymph which, according to the theory of that day, became organized, that is, was endowed with an independent power of forming tissue. As the external clot was absorbed it was replaced by this coagulated lymph, the vessel in the mean time contracting up to the first branch, a delicate ligament being eventually all that remained. In partial division of the vessel, this writer tells us, a coagulum forms between the vessel and its sheath at the point of injury, and the wound in the wall is closed with coagulated lymph, which subsequently forms outside as well. Wounds less than one-fourth the circumference of the vessel in animals are capable of healing so as to occasion little or no obstruction in the canal, and rarely do such injuries lead to aneurism—a curious fact noticed by all subsequent experimenters. If the artery be surrounded by a tight ligature the middle and internal coats will be completely divided as if by a knife, the external coat remaining entire, upon the strength of which coat very much depends. He speaks of the "ulceration of the ligature," which expression at the present time, when both ends of the knot are cut short and it is allowed to heal in, conveys a false impression of the nature of the subsequent changes. The process of repair is essentially the same as that already described. He was inclined to attach too little importance to the thrombus, or internal coagulum, as he called it; and in ordinary accidents he thought it contributed nothing to the suppression of hemorrhage. Jones' views were generally accepted, but, since he differed essentially from Hunter respecting the rôle played by the internal thrombus, this question now became the chief subject of discussion, one party maintaining that the thrombus was organized and formed the cicatricial tissue; the other believing that this function was performed by the walls of the vessel, which were supposed to be united by an adhesive inflammation. In France the majority favored Hunter's views, though Andral believed with Cruveilhier in the correctness of the latter theory, as did also Guthrie in England. In Germany opinions were about equally divided until Stilling, by an elaborate series of researches, the most extensive since those of Jones, seems to have definitely settled the question that the thrombus did become organized. Guthrie also established the fact that a longitudinal slit in human arteries of medium size, as the temporal, may heal without obliteration of the vessel, and that in vessels of considerable size hemorrhage may be arrested without aid, the power and influence of the heart over the circulation through the arteries being greatly overrated; a fact also observed by Velpeau.

With the rise and progress of histological research the question of the organization of the thrombus was subjected to new tests. Schwann, in 1838, had developed his "cell theory," that it was only through the intervention of cells that further development could take place, and not, as Henle still maintained, through an amorphous blastema formed from coagulated lymph, which could be directly changed into new tissue.

Rokitansky called attention to the changes taking place in vessels which had been excluded from the cir-

culation owing to a change in the current of the blood, as the umbilical arteries and the *ductus Botalli*, and he pointed out that the process was the same in ligatured vessels. It was not, in the opinion of this writer, through the intervention of a thrombus, but through a collapse in the walls and their subsequent fusion by the deposition of a new layer, that obliteration took place. Virchow, who was at first more or less influenced by the views of Hunter, as he became convinced of the power of cell action and inaugurated the theory of "*omnis cellula e cellula*," discarded the views of Schwann and Henle, and saw in the white corpuscles of the thrombus the organizing elements. Although he conceded that the vessels in the thrombus might be developed from the vasa vasorum, still he did not think that the presence of the cellular elements of the new tissue could be explained by a primary growth inward of the cells from the vessel wall. Both he and Rokitansky recognized that the spaces filled with fresh blood were not new-formed vessels, but channels hollowed out by the blood current which are to be distinguished carefully from the vascularization of the thrombus. This process was termed by Virchow the "sinus-like degeneration"; the term "cavernous metamorphosis" has also since been applied to it by Rindfleisch. The latter likened the thrombus to a tissue, of which the white corpuscles were the cells and the red corpuscles and fibrin were the matrix and the gradual series of changes of the white corpuscles into connective-tissue cells were described both by him and by O. Weber, who also thought that new blood-vessels were formed by them which subsequently united with the vasa vasorum. It was by these observers that the theory of the organization of the thrombus received its fullest elaboration.

Attention had, however, already been called, both in France and in Germany, to the action of the lining membrane of the vessel, and the views of the above-mentioned writers were further strengthened by an important communication from His, who showed that the endothelium was of an essentially different origin from the epithelium of the skin and mucous membranes, and belonged rather to the group of connective substances.

Waldeyer thereupon concluded that the endothelium was capable of producing a young connective tissue within the vessel, which tissue was subsequently vascularized by vessels springing from the vasa vasorum, and that the thrombus was absorbed as this tissue grew into it. The same thing, he thought, occurred in the blood clot in extravasation, the process of organization always taking place at the edges only.

The investigations of Recklinghausen on the wandering cells, and of Cohnheim on the passage of the white corpuscles through the walls of blood-vessels, turned the discussion into a new channel. The theory of the organization of the thrombus was now virtually abandoned, and the dispute, as to the origin of the cells found in the thrombus, now lay between those who derived such cells from the endothelium and those who assumed that they had wandered in through the walls of the vessels. While the views of Cohnheim, as to the origin of the new cells in inflamed tissues, were adopted by a large number of pathologists, there were still many who believed that the pre-existing cells of a part were capable of proliferation.

The study of endarteritis appears to have convinced most observers that the growths which eventually obliterate the smaller vessels arise from the internal tunic. A growth of mucous tissue is sometimes seen under the endothelium; at other times its upper layer also appears to be involved; and, if coagulation of the blood occurs, the cells may grow into the clot so formed. According to Cornil and Ranvier, a further growth of such tissue in larger vessels will lead to a breaking down of the media, and to a growth of cells outward into the adventitia. A number of observers have found a new formation of vessels in the obliterated artery produced by the force of the blood current forming a channel. Around such spaces may be seen newly formed elastic laminæ, constituting a newly developed wall for the new vessel, which thus does the work of a collateral branch. Analogy would suggest a growth also of the internal tunic in vessels after ligature, and Cornil and Ranvier, indeed, consider the two processes identical.

The weight of opinion latterly has been decidedly in favor of the activity of the inner tunic of the vessel in the healing process after ligature. Such is the view of those who have studied the subject in this country during recent years. Shakespeare derives the new formation from the endothelium and subjacent cells of the intima. A collection of these cells is to be found at the point of ligature at the end of the first twenty-four hours, forming a cushion upon which the clot is seen to be resting. To this new growth Shakespeare gives the name "plastic clot." The thrombus, or "fibrinous clot," takes no part in the process, but is pushed up by the plastic clot, in which latter signs of vascularization begin to show themselves as early as the sixth day, communication being effected with the vasa vasorum between the fifteenth and thirtieth days.

Senn finds that the cicatrix is the exclusive product of connective-tissue and of endothelial proliferation, and that permanent obliteration takes place in an artery in from four to seven days. This would imply a reliance chiefly upon the intima for the production of the new tissue.

Thoma has elaborated the views of Rokitansky on the analogy with the closure of the umbilical arteries and the *ductus Botalli;* and he has described the formation of a hyaline and fibrillated connective tissue in the deeper layers of the intima, as a compensatory endarteritis occurring at birth in that part of the arterial system specially concerned in the fetal circulation, in the arterioles of the kidneys in chronic nephritis, and in the stumps of arteries after ligature. The closure of an artery, he says, whether it occurs physiologically or as the result of an operation, depends upon the slowing of the current. It begins with a contraction of the media; if this contraction be enough to restore the normal rapidity of the circulation, further changes are confined to an atrophy of the muscular wall sufficient to correspond with the diminished calibre and diminished tension. If this change does not suffice, it is supplemented by a compensatory thickening of the intima. The observations of Schultz respecting the shape of the cicatrix in an arterial stump, on its elongation or thickening upon one side of the vessel according to the proximity of a branch, are in this way explained.

As to the cause of formation of the thrombus, Cohnheim takes the ground that it is due to an injury to the endothelium; the old view that it might be produced merely by a slowing of the current not holding good, for even in marasmic thrombi we find slight injuries to the internal membrane; moreover, a ligature may be put around the vessel without producing coagulation, provided the endothelium be not injured. Baumgarten thought to avoid formation of a thrombus by keeping the wound aseptic, but we find no other such observations recorded.

The shape of the thrombus is usually represented as ovoid, the apex, which is unattached, being directed toward the lumen of the vessel; the proximal thrombus is usually longer and always broader than the distal thrombus. Bryant explains the ampulla-like dilatation of the proximal end by the more rapid coagulation of blood here, which coagulation is attributed by Lister and Callendar to the greater turmoil into which the blood is thrown on the cardiac side by impinging against the obstruction, the churning process leading to the deposit of fibrin more or less pure; but they also agree that the deposit of blood clot is favored by slowness of movement, as on the distal side in the lower extremity when the anastomosis is not free.

It will be observed that those histologists who have interested themselves in the repair of arteries have considered the question usually from some special standpoint, such as the "organization of the thrombus," the rôle of the white corpuscles, of the wandering cells, or of the endothelium. We shall now undertake to follow the

various pathological changes which occur in and around the vessel from the time the ligature has been applied until the process of cicatrization has been fully completed. These changes may be compared not inaptly to those which occur in long bones after fracture. In both we find an external and an internal callus, in both there

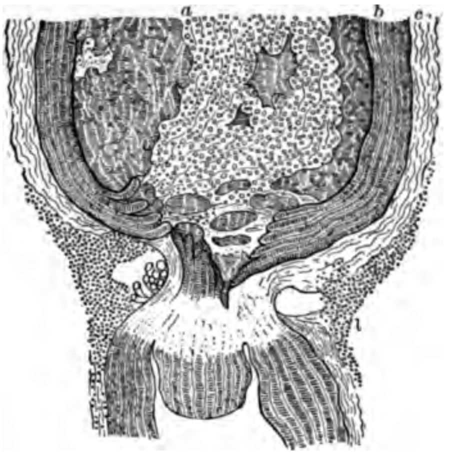

FIG. 319.—Ligatured Vessel. *a*, Proximal thrombus in ampulla-like dilatation of the vessel; *b*, media; *c*, adventitia; *l*, site of ligature. (Drawn from author's specimen.)

is a growth of tissue which has only a provisional existence, and in both the dense walls subsequently undergo certain changes which enable them to take a tardy but important part in the final cicatrization. In arteries, however, the external callus produces a ligamentous union only between the two fragments.

When a large artery is tied in its continuity, the intima and a variable portion of the media are usually ruptured, and the adventitia is gathered into a dense tendinous sheath around the constricted ends. The first noticeable change is the formation of the thrombi, which are usually developed within the first twenty-four hours, and the accumulation of a granulation-like mass of cells about the ligature, which, if it has been cut short, is completely enveloped by them. This growth appears to proceed from the periadventitial tissue, and varies according to the amount of injury done by the ligature to the vessel walls, or to the irritation which it produces. If the coats of the vessel have been unnecessarily bruised and a certain amount of extravasation has taken place in consequence, or if the ligature itself, for some cause, has created irritation, the surrounding inflammatory tissue will form a well-marked callus. If an excessive irritation has been produced, the growth of this protective tissue may be retarded, or it may be destroyed and the danger of hemorrhage correspondingly increased. Following the development of this external growth, we find that it extends some distance up and down the sides of the vessel in the periadventitial tissue, the round cells of which it is composed invading only the superficial layers of the adventitia; the breadth of the growth is, of course, greatest at the point of ligature; in length it reaches usually to a point on a level with the ends of the two thrombi; when fully developed it is consequently spindle-shaped (Fig. 319). At the point of ligature, where the fibres of the outer wall are densely packed (Fig. 319, *l*), the wandering cells do not penetrate during the first few days; but just above and below the ligature they may be found already invading the media as early as the second day; occasionally the apex of a pyramidal-shaped mass of such cells will have reached the thrombus. These cells appear to exert a solvent action on the bunch of fibres projecting from the ring of the ligature, which thus becomes gradually liberated from all connection with the vessel, the two ends of which now retract and leave the knot embedded in the centre of the callus. The fibres of the ligature itself soon become infiltrated with cells, and by the tenth day they may have already disappeared, or, if its resisting powers are greater, may remain encysted for some time. The period which the ligature requires for this separation varies greatly according to the size of the vessel and character of the ligature, and is longer in man than in animals. If the artery has been properly dissected out, this external growth will be observed forming a callus-like ring, in which the two ends of the vessel are embedded, in size about twice the thickness of the vessel, and it can still be seen well developed at the end of two months (Fig. 320). In the specimen from which the accompanying drawing was taken the ligature had caused suppuration about it, and had formed a fistulous track at the fundus of which some fibres were found still remaining. By the end of three months the external callus has disappeared, and only a slender cord unites the peripheral to the proximal end.

Already by the fourth day changes are noticed within the vessel. Observing the proximal thrombus we find an increase in the number of white corpuscles, particularly near the point of ligature, not in an isolated mass, but mingled with red corpuscles. Masses of coagulated fibrin with young cells (white corpuscles of clot, wandering cells from arterial coats, and rarely also peri-arterial tissues) are attached to the frayed ends of the media which have been cut by the ligature, and are more or less inverted. The endothelial cells, when not firmly compressed by the thrombus, as in the distal end, are in a state of activity, undergoing proliferation to a moderate extent. Occasionally, loop-like masses of cells may be seen projecting into the clot, or a delicate anastomosing network of stellate or spindle-shaped cells; but the total amount of this cell growth is small as compared with the size of the thrombus. In the mean time, in the second week, masses of granulation cells are seen infiltrating that part of the wall which is separating or has already separated from the ligature. Even at this period, with the external growth carefully dissected away, as is the custom in museum specimens, the vessel appears to have united by first intention, that is, by a direct union of the media and intima side to side. But the infiltration and softening continue until the walls are separated and expand, like the petals of a rose, yielding before the advancing growth of granulation tissue. The deeper portions of the clot are now infiltrated with two growths; the more superficial (that is, the portion nearest the open lumen of the vessel) is composed of tissue grown from the intima and media and wandering cells, and the deeper is composed of vascular granulation tissue which has pushed its way in from without. Viewed at the third week, the ends of the vessel will be found expanded and the space between them filled with well-formed granulations, such as are seen on the surface of a healthy wound. A portion of the thrombus, sometimes a large portion, has not been infiltrated, but is attached firmly to the top. A longitudinal section of such a specimen gives a striking illustration of what is understood as "healing by scabbing." As the clot shrinks the spaces left between the granulations, which have now rolled over one another in cloud-like masses, become continuous with the open

FIG. 320.—Carotid Artery of Horse Two Months After Ligature. *l*, Sinus at site of ligature; the ends of the artery have separated, but are enclosed in a firm callus. (Drawn from author's specimen.)

lumen of the vessel, and the so-called "canalization" of the thrombus is thus effected. An injection mass can be forced from the vessel for some distance into these spaces, but as yet they do not communicate with the vessels of the granulation tissue. This communication usually does not occur until the second month, that is, until the provisional growth has reached its period of highest development. The vessel walls have in the mean time been undergoing certain changes. A proliferation of the cells of the intima, as has been noticed by so many observers, unquestionably takes place; but the amount developed is not sufficient to supply more than a very small part of the provisional tissue. The cells, however, have begun to grow before the other tissue has made its way into the vessel, and at this period serve the purpose of attaching the thrombus to the walls of the vessel, but even in this work they are aided by other cells from the media. They also furnish a new endothelial covering to the permanent cicatrix, and a lining to the new vascular spaces that have been formed. When the elastic lamina has been ruptured (and this is frequently seen on the sides of the vessel near the ligature, and also here and there higher up as far as the thrombus extends), we find an intimate connection at such points of the media with new growing tissue within the vessel. In the second week, cells may be seen springing from the media and growing into either the clot or a clump of cells attached to the inner wall. The cells are round and spindle-shaped, frequently in bundles. Evidences of cell activity in the media are abundant, and in some specimens in animals a proliferation of the muscular cells through the whole thickness of the media is observed, giving a considerable increase to the width of this layer. The elastic lamina is frayed out at its divided end, and glistening elastic fibres are seen extending downward into the external growth as the two ends of the vessel gradually retract from each other. At the end of three months the provisional tissue has been absorbed, and we find the walls united by a permanent cicatrix which joins the sides of the vessel, still somewhat separated from each other. It consists, in medium-sized arteries, of a crescent-shaped mass of tissue, the concave side of which faces the lumen, while the horns run up on either side of the vessel. One horn may be long and the other short,

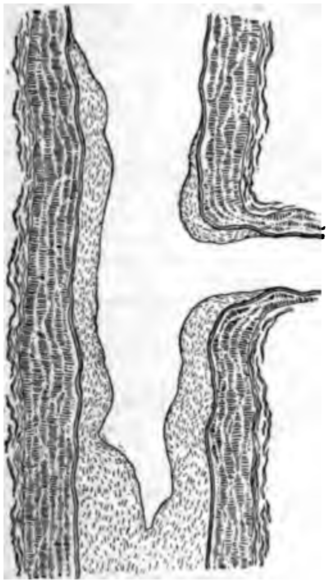

FIG. 321.—Carotid Artery of Dog Four Months After Ligature, showing shape of cicatrix as modified by the presence of a branch. (Drawn from author's specimen.)

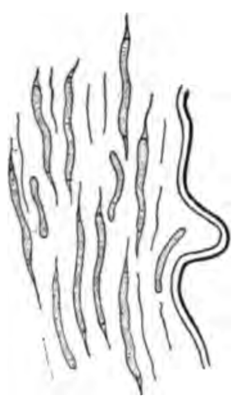

FIG. 322.—New Muscular Cells in the Cicatrix; from the femoral artery of a dog three months after ligature. (Drawn from author's specimen.)

the crescent being placed somewhat excentrically. The longer horn may be sometimes thickened (see Schultz and Thoma), as in Fig. 321, if a branch lies opposite to it. In the largest vessels the cicatricial tissue occupies a considerable portion of the calibre of the vessel.

On the surface of the cicatrix is seen a thin layer of endothelium; beneath this, in medium-sized vessels, there can be seen a layer of delicate, tapering, spindle cells with staff-shaped nuclei, forming a continuous layer from one horn to the other. They run parallel to one another and to the arc of the circle made by the crescent, and resemble in all respects muscular cells; in short, a genuine muscular layer is found here (Fig. 322). Beneath this layer is a mass of cicatricial connective tissue which plugs the space lying directly between the ends of the retracted walls (Fig. 323). The cicatrix is pierced by a vessel of considerable size which rapidly tapers to a point and anastomoses with a capillary network, ramifying both in the cicatrix itself and in the ligamentous band outside. This central vessel, which in larger cica-

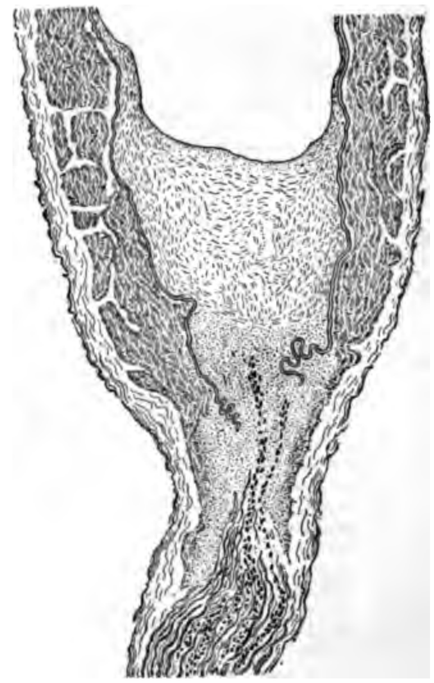

FIG. 323.—External Iliac Artery of Man One Hundred and Thirty Days After Ligature: formation of permanent cicatrix. (Drawn from author's specimen.)

trices becomes tortuous and gives to the cicatricial tissue a "cavernous" appearance, may be regarded as the unobliterated residuum of the lumen.

We find in this anatomical peculiarity of the cicatrix an explanation of its immunity from aneurismal dilatation. The protective influence of the thrombus enables the process of cicatrization to complete itself before the cicatrix is called upon to withstand blood pressure, and it is then armed with a muscular coat (as is the normal vessel wall), which acts not unlike a levator ani muscle in sustaining and modulating the force of the blood column.

The ligament which unites the two ends of the vessel represents, in part, the residue of the external callus; it has become much elongated by the retraction of the two ends. During the healing process, a small portion of the vessel walls has become disintegrated by the new growth, and a portion has atrophied and has been absorbed, the remaining walls have shrunk greatly by retraction, and their calibre has been filled to a greater or less extent by a cicatricial tissue; so that the vessel has

become practically obliterated up to the first branches of the collateral circulation.

The thrombus is a mere passive structure, and takes no part in the growth, but is protective and affords an excellent medium for the germination of the new tissue.

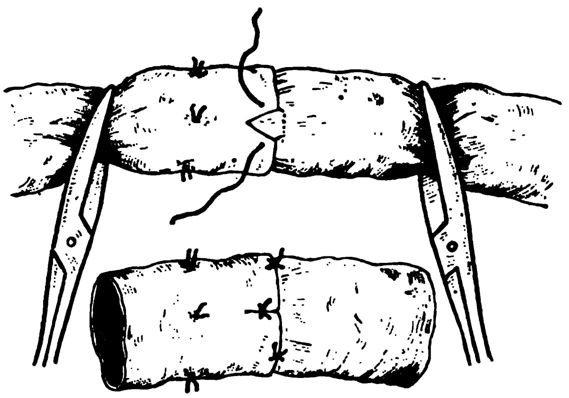

FIG. 324.—Method of Inserting External Sutures. (After Murphy.)

Its upper portion is not penetrated by the new growth, but rests upon it and forms a sort of protecting scab. It is deposited gradually, and has a stratified appearance. Its size appears to be dependent upon the amount of injury done to the vessel and the resulting inflammation. If the intima or the elastic lamina has been ruptured in handling the vessel, as can frequently be demonstrated by the microscope, some distance from the point of ligature, clots will form at these points, and the thrombus will thus become elongated. Occasionally, the apex is formed of white corpuscles only, and may be free or lightly attached to the wall by a cell growth from the intima. The distal thrombus is shorter than the proximal, and much narrower, so that there is but little difficulty in distinguishing them from each other.

It was at one time the custom to place a double ligature upon large vessels, in place of a single ligature, and to divide the vessel between them. This procedure was advocated by Jones, who says: "In the single ligature, although the knot is soon covered up and protected by an effusion of lymph, it is placed in the centre of a portion detached from the surrounding cellular membrane, and the process of repair cannot go on so well, as the nutritive vessels are cut off. In the double ligature, the knots are placed where the connection of the vessel with the surrounding tissues is complete."

This theory has recently been revived by Walsham, who considers the separation of the artery from its sheath as important a factor in influencing the result as tightness of the ligature or division of the coats, inasmuch as the vitality of the artery depends in a great measure, he thinks, upon the blood supply received from the sheath. But Holmes objects to this method on account of the free dissection and exposure of adjacent vessels rendered necessary: if the knot "will keep its hold on the vessel until the seat of the ligature is buried in a mass of new fibroid material, secondary hemorrhage, if not impossible, is, at least, very improbable." The method, he says, has passed out of use when secondary hemorrhage was common, to be brought back when it is rare.

The supposed danger to the vessel wall, incurred in applying the single ligature, is based upon anatomical rather than upon pathological conditions, and, in the light of present knowledge, is a theoretical rather than a practical objection.

Murphy has recently experimented with sutures of veins and arteries. In suturing lateral openings of arteries the sutures should enter only the adventitia and media, the intima being avoided to prevent endarteritis. The sutures should be inserted every one-sixteenth to one-twentieth of an inch. Hemorrhage from needle punctures may be controlled by gentle pressure. If necessary to resect a portion of the artery not more than three-fourths of an inch should be removed.

Murphy's method of invaginating the ends of the vessel is shown in Figs. 324 and 325. Twisted silk is used for sutures and eight-inch Billroth compression forceps with broad blades and catch are employed to control the ends of the vessel. The blades are covered with rubber tubing to protect the vessel. In order to facilitate the invagination a small incision is made parallel to the long axis of the vessel extending for a distance of from one-fourth to one-third inch. The arterial blood pressure tends to press the walls closer and thus prevent hemorrhage.

Murphy has successfully treated the femoral artery in this way in a man twenty-nine years of age. The artery was perforated by a bullet, which also caused a linear wound of the vein which was sutured.

LIGATURES.—It was chiefly due to Jones' investigations that the modern single thread found at one time almost universal adoption. Cutting short both ends of the knot was adopted as long ago as 1798 by an American naval surgeon. The disadvantages of a silk or hempen ligature were supposed to be due to its non-absorption and the liability to produce suppuration, but the ordinary silk or hempen ligature, if cut short, will eventually be absorbed.

The introduction of the animal ligature is generally ascribed to Physick, whose ligatures were made of chamois leather rolled on a slab, to render them hard and round. Sir Astley Cooper tried them, and they were used in this country on all the large vessels by Jamieson, of Washington, who advised using the buckskin soft and a little broader than the ordinary thickness of the skin.

The most common form is the catgut ligature. It is prepared from the small intestine of the sheep by scraping away the muscular and mucous coats, all that remains being the submucous cellular coat and a narrow strip of peritoneum. The translucent membranous tube which remains can be twisted entire for the coarser forms of catgut, and is then dried. For the finer kinds,

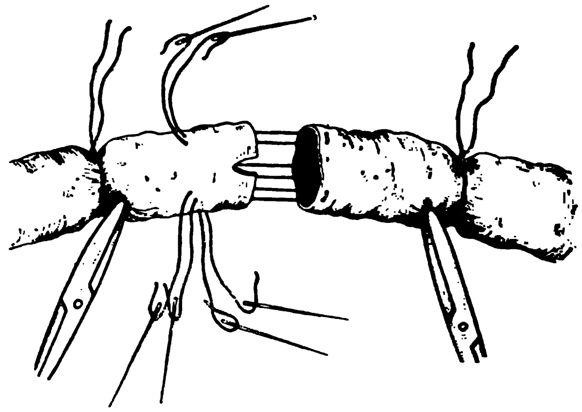

FIG. 325.—Method of Inserting Sutures to Produce Invagination. (After Murphy.)

the submucous coat is split by means of razor blades, more or less numerous, according to the degree of splitting required, and connected with a conical piece of wood which is pushed along the tube. If it has not been properly prepared, the substance of the catgut becomes converted in the course of a very few days after the application of the ligature into a soft, pultaceous mass, which, when we examine it by a microscope, we find to consist of remains of the old cellular tissue of the submucous coat, the interstices among the fibres being filled with cells of new formation. The catgut tissue is infiltrated with young growing cells, and it is obvious that it is this infiltration which is the cause of

the softening; but, on the other hand, if the catgut is properly prepared, instead of being infiltrated by the cells of new formation it is only superficially eroded. Until nearly a fortnight has elapsed, erosion does not begin. It then proceeds gradually, and, therefore, the

FIG. 326.—Ballance and Edmunds' "Stay Knot"; Floss Silk Ligature; First Stage.

thicker the catgut the longer is the time required for its complete removal. We may fairly consider that from a fortnight to three weeks is long enough for the persistence of a ligature upon an artery in its continuity. If over-prepared—that is, rendered too hard by the chromic acid—it may be discharged whole, as in the case of the hempen ligature quoted. Many of the failures with catgut can be referred to improper modes of preparation; and although the danger of obtaining a material that is too readily dissolved is not so great since the introduction of the chromicized gut, the necessity of being so dependent upon the care of the manufacturer constitutes a certain objection to its use.

Other forms of ligature are those prepared from the kangaroo and whale tendons.

Barwell has proposed, in the treatment of aneurism, the use of the ox-aorta ligature, which can be applied so as not to divide the internal coats, and need not ulcerate through the artery. He thinks it becomes organized, having seen remains inseparably mixed with the surrounding tissues fifteen months after it had been applied. In other cases it is absorbed. It is prepared by cutting spiral strips from the aorta. A weight is attached to the end of each flat band thus produced, and the band is hung up and dried. Just before use it may be moistened in a solution of carbolic acid.

FIG. 327.—Ballance and Edmunds' "Stay Knot" Completed.

Dent reports a case of the application of the tendon ligature to the carotid and subclavian arteries followed by death at the end of ten days. In an examination of the carotid, the knot of the ligature was found in close contact with the artery, encysted in a small cavity in the effused lymph. The knot was almost gelatinous in appearance. Transverse sections showed that the external coat of the artery "was not ulcerated," and this condition is considered due to the slight swelling and softening which such a ligature undergoes. New blood-vessels were found developed in those parts of the tendon which lay close to the artery; that is, rows of spindle-shaped cells, with spaces between, were seen branching in the tendon tissue, and blood-vessels were seen passing into both the artery and the tendon; the tendon was also infiltrated in other portions with granulation cells; some of the adjacent muscular coat was being attacked and eaten away. This question of the organization of the ligature was first raised by Lister, who now explains that he does not mean that the catgut comes to life again, but "new tissue forms at the expense of the old, that the old tissue is absorbed by the new, and that as the old is absorbed new is put down in its place." Evidently he is here describing the formation of the provisional tissue, or external callus, and the gradual absorption of the ligature. The observations of Dent may be interpreted in the same sense, the granulation tissue pushing its way into the interstices of the knot preparatory to "eating it away," as it already has done portions of the muscular coat. In Barwell's case the preservation of a distinct band, fifteen months after ligature, may be accounted for by supposing that the ligature had not been wholly absorbed. Much misconception has arisen from an improper preparation of such specimens. In order properly to appreciate existing conditions, the vessel should be removed with the surrounding inflammatory tissue attached to it, should then be placed in some hardening fluid for a few days, and, finally, a longitudinal section, with a sharp razor, should divide it into equal halves.

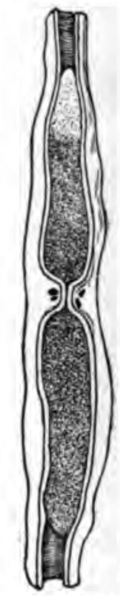

FIG. 328.—Common Carotid of Horse Fourteen Days After Ligature; approximation of vessel walls without rupture, by two square knots. (Ballance and Edmunds.)

Ballance and Edmunds call attention to the danger of failure to close the lumen of an artery ligatured in continuity by the ordinary single ligature. This is due to the loosening of the first half of the knot while the second half is being tied. They recommend the "stay knot." Floss silk is employed and two ligatures are placed close to each other and the first half of each knot is tied in the usual way. In the second half of the knot the two ends on each side are treated as one and the second hitch is tied as if completing an ordinary reef knot. The knot should not, according to these authors, be tied so tight as to rupture the inner walls, but only so as to place them accurately in apposition. The danger of hemorrhage or of aneurismal dilatation, they claim, is thus avoided. (See Figs. 326, 327, and 328).

In large arteries ligatured in continuity a stout braided silk ligature will hold the wall of the vessel firmly in contact after the first half of the knot has been tied for a sufficient length of time to enable the surgeon to complete the knot, and is, owing to its simplicity, to be preferred to the "stay knot."

Metallic ligatures have not been favorably received, though satisfactory results have been reported, a number of such ligatures not interfering with union by first intention. The difficulty of regulating the tension of the ligature, and the amount of consequent injury to the vessel, appear to be the chief objections to them for ligature in the continuity. To smaller vessels they are not so easily applied as are pliable ligatures.

TORSION was not unknown to the ancients, as has already been shown, and was employed by certain surgeons in the Middle Ages; but in more modern times, surgeons were not familiar with it until it was brought to the notice of French surgeons by certain statements of a visitor from Germany. Both Velpeau and Amussat apparently claimed the credit of introducing it, the former in consequence of his experience, when a student with a veterinary surgeon, in the twisting of the pedicle in spaying and castration, and both as the result of their observations on the immunity from hemorrhage in lacerated arteries. The method employed by Velpeau is thus

described: "After having seized the vessel by its extremity, I separate it from the surrounding tissue, and grasp it, at its deepest point in the wound, with another forceps, to hold it firmly while it is turned on its axis, three to eight times, by the first pair of forceps." He appears to have employed the method in several amputations. Its supposed advantage was the avoidance of a foreign body in the wound. He recognized the fact that animal ligatures would be equally good for this purpose, and also the disadvantage of torsion in diseased vessels, and that small vessels were not easily isolated. It was, perhaps, for these reasons that, although tried thoroughly by some of the leading surgeons in France and Germany, it fell into disuse until revived by Bryant, in England. The effect of torsion, according to the latter, is a twisting of the elastic fibres of the adventitia beyond the end of the vessel, and a retraction and incurvation of the middle and inner coats; the twist in the outer coat is permanent and cannot be unfolded by any legitimate force; the middle and inner coats are retracted in the direction opposed to the blood stream, approximated and overlapped. They sometimes assume a nipple-shaped projection, at other times a valvular form, being not unlike the semilunar valves of the heart, and closing as perfectly; in some cases, again, they appear to split; in all, the coagulation of the blood is favored. The safety from hemorrhage, according to Bryant, rests upon the twist of the external, the retraction of the internal coats, and the coagulation down to the first branch, while, in acupressure, the permanent safety depends upon the last alone, temporary protection being afforded by the needle.

Kocher found numerous and irregular lacerations of the inner coats over a considerable distance of the wall, and independent of one another, while in ligature the ruptures were circular and only close to the point of ligation. In unlimited torsion there is considerable narrowing of the lumen. Owing to these peculiarities, it has the advantage of favoring a rapid coagulation.

The effect of the limiting forceps in bruising the inner wall of the vessel, and thus favoring both coagulation and repair at the bruised spot, is noticed by Shakespeare, who recommends a similar bruising in ligature (the "modified ligature"). The process of healing is, according to the latter observer, the same in its essentials as that which occurs after ligature.

Acupressure.—The introduction of this method of hæmostasis is to be accredited to Sir James Simpson (unless an obscure passage in John de Vigo's writings be interpreted otherwise than as a description of the ordinary ligature). He saw in the ligature a foreign body in the wound which cut through the two coats at the time of its application, and ate through the outer coat by a process of ulceration, mortification, and gangrene. Variations in the shape or material of the ligature did not overcome these disadvantages. It was for this reason principally that amputation stumps healed with so much greater difficulty than wounds in the operation for vesico-vaginal fistula, although the latter were constantly bathed in leucorrhœal discharges and urine. The application of the ligature isolated a portion of the end of the vessel, which remained in the wound as a piece of dead flesh until it came away with the ligature. The needle, on the other hand, did no injury to the vessel and caused no irritation, its use being based upon "the great pathological law of the tolerance of living tissues for the contact of metallic bodies embedded in their substance." Bryant showed, however, that the ligatured portion did not slough, but became adherent and vascularized. Even though the vitality of such a fragment be completely destroyed, it need not become a slough unless another element, that of decomposition, be introduced, and may, therefore, be surrounded by healthy granulating tissue and become disintegrated and absorbed by a process already described.

Although English surgeons supposed that no injury was done to the vessel by the needle—Hewsen expressly states that no laceration of the internal coat takes place, and Shakespeare does not mention any alteration of the tunics—Kocher and other German writers have demonstrated longitudinal slits in the intima, but not so extensive as those occurring in torsion. The vessel is thrown into longitudinal folds, which become sufficiently firmly glued together to retain this shape long enough, after the removal of the needle, for the thrombus to form and become firmly attached to the walls. A specimen examined by Kocher at the end of twenty-two hours showed no thrombus, the walls being compressed and somewhat thickened, but a fine probe could be introduced between them. At thirty-six hours a well-formed, egg-shaped thrombus is represented by Shakespeare. A drawing by Kocher shows a specimen fourteen days old, when the walls have already separated from each other, and the thrombus is short and wide, having a concave surface on the side toward the lumen, and a convex surface at the other end. The relation which the thrombus bears to the vessel is that of a cork to a bottle, beyond the neck of which it does not project. It is probable that the apex had been detached. Hewsen also mentions that the thrombus is confined to the compressed spot. The final cicatrix has a shape similar to that described as following ligature, and is developed by a similar process of repair. In acutorsion, the lumen of the vessel is narrowed for some distance from its extremity.

In acupressure, in the continuity, the proximal and peripheral ends of the thrombus are continuous, as are also the walls of the vessel, which at first are thickened by a connective-tissue growth; the subsequent changes differ in no way from those already described.

Ogston has tested mechanically the comparative strength of arteries secured by ligature, acupressure, and torsion, by subjecting them to the pressure of a column of mercury. It was found that a column one hundred and fourteen inches in height was insufficient to rupture the ligatured artery. Twisted vessels unfolded at an average height of thirteen inches (or a pressure of 6.5 pounds to the square inch). Estimating the internal blood pressure at from two to eight pounds to the square inch, he concludes that it would appear likely that vessels secured by torsion are very liable to secondary hemorrhage, especially when the heart, recovering from the immediate shock of an operation, begins to beat more forcibly. In acupressure, the column of mercury showed an average height of 23.5 inches. It would, therefore, seem a more reliable method, he says, than torsion, and less reliable than ligature. According to Shakespeare, the healing process is slower both in acupressure and torsion than in ligature.

A procedure somewhat similar to acupressure has been described by Pollock; it consists in substituting a silver wire for the ligature, the ends being brought out through the skin covering the lips of the wound and twisted together. They are allowed to remain, on an average, five and a half days, and the results of this procedure have proved satisfactory. *J. Collins Warren.*

ARTHRITIS DEFORMANS.—(Synonyms: Rheumatoid arthritis [Garrod]; chronic rheumatic arthritis [Adams]; nodosity of the joints [Haygarth]; osteoarthritis; French, *rhumatisme noueux*; German, *rheumatische Arthritis*.)

Definition.—A chronic, progressive disease of the joints, affecting chiefly the articular cartilages, bones, and synovial membranes, and producing loss of function and great deformity.

History.—Arthritis deformans is a disease of great antiquity. The chiragra of Horace and other early writers was in all probability deforming arthritis of the fingers. Celsus refers to it, and Aretaeus[1] describes the appearance of nodules (πῶροι) on the joints which fairly correspond to those seen in this disease. All doubt that might yet remain as to the existence of the disease in the most ancient times has been removed, however, by the finding of bones bearing the characteristic lesions in the ruins of Pompeii,[2] in Egypt,[3] Pomerania, and elsewhere.

One of the earliest distinctive references to the disease in the older literature is that of Sydenham,[4] who clearly

described the clinical manifestations, but attributed them to rheumatism. Musgrave,[5] Haller,[6] de Sauvages, and others describe more or less definitely one or other form of the disease. Landré Beauvais,[7] in 1800, was the first to investigate its pathological lesions, the destruction of cartilage, and the new formation of bone; but, although he described these as belonging to a definite disease which he designated "Goutte asthénique primitive," it can hardly be claimed that he clearly differentiated them from the morbid changes that result from gout and other affections of the joints.

It remained for Heberden,[8] in 1804, to recognize characteristics which, he suggested, should distinguish the disease from both true gout and true rheumatism. He was at the same time the first to describe the peculiar nodes which sometimes form upon the terminal joints of the fingers and which are still known as Heberden's nodosities. In the following year Haygarth[9] published a monograph on "Nodosities of the Joints," based upon his clinical experience in thirty-three cases, all women, which early convinced him that there is a "painful and troublesome disease of the joints, of a peculiar nature, and clearly distinguishable from all others by symptoms manifestly different from the gout, and from both acute and chronic rheumatism."

The views expressed by Heberden and Haygarth were evidently but partially accepted at the time, for several authors who followed them failed to differentiate this form of arthritis from gout and rheumatism. Comparatively little was written on the subject, however, until the works of Brodie[10] and Adams[11] and the magazine article of Robert Smith were published.[12] These authors accepted the doctrine of the entity of the disease and did much to elucidate its pathological anatomy. To Adams belongs the credit also of having demonstrated that the so-called morbus coxæ senilis of men is pathologically the same affection as the deforming arthritis of the small joints more frequently seen in women. The recognition of the individual nosology of the disease was for a long time checked, in France at least, by the graduation theses of Charcot[13] and Trastour in 1853. They maintained that it was merely a form of chronic rheumatism, and the opinion was accepted by nearly all French writers until quite recently.

The morbid anatomy, first studied, as we have seen, by Landré Beauvais, was further elucidated in the writings of Cruveilhier,[14] Aston Key,[15] Lobstein,[16] Broca,[17] and others. Fuller[18] and Garrod[19] made valuable contributions to the literature of the affection, and so aided materially in establishing both its pathological and its clinical identity. Garrod went so far as to demonstrate that the presence of an excess of uric acid in the blood, a feature of gout, was not to be detected. Rokitansky, Förster, Virchow, and Volkmann should also be named in the list of those who investigated its morbid anatomy.

J. K. Mitchell,[20] in 1831 and 1833, suggested the nervous origin of rheumatic diseases. He was followed many years later by Senator, Ord, and other authorities, until this has become the most generally accepted theory with reference to deformative arthritis. The name arthritis deformans was introduced by Virchow.

Etiology.—The idea that arthritis deformans is in any way related to either rheumatism or gout is no longer tenable. The disease may occur, however, in persons whose family histories show the taint of gout or rheumatism or in those more or less subject to either of these affections.

It may occur at any period of life, but the frequency of its onset is increasingly greater from thirty-five to fifty-five, rapidly declining after the latter period. It is much more frequent in women than in men, commencing in most cases during or after the menopause and somewhat oftener in those who have been sterile. Occurring earlier in life, it sometimes follows rapid child-bearing. Uterine disease was a prominent feature in the etiology of 26 of the 33 cases reported by Ord.[21]

Heredity plays at best a doubtful part in the etiology. As A. E. Garrod[22] intimates, statistics regarding the family history are of little value except in those rare instances in which several generations or their recorded histories have come under the observation of one physician, so great is the confusion in the minds of the laity with reference to gout, rheumatism, and arthritis deformans. His statistics of five hundred cases from private practice, he concludes, "lend countenance to the idea which was formerly very prevalent that there exists an arthritic diathesis a predisposition to arthritic disease, upon which gout, rheumatism, or arthritis deformans is apt to be developed." The daughters of gouty fathers are supposed by some authors to be especially predisposed.

Exposure to cold and wet is believed to have less influence in the induction of arthritis deformans than it has in rheumatism. It nevertheless appears to have had an influence in the development of some cases and undoubtedly may increase the suffering; but temporary exposure is probably of much less consequence than is residence in damp quarters. Bad hygienic surroundings, insufficient or improper food, and exposure are given as important factors in producing the disease in children.

Mental and nervous depression, worry and care are recognized as exciting causes and are capable of producing exacerbations. The exhaustion of nerve centres by sexual indulgence and the leading of a dissolute life have been named by Weber[23] as potent factors in some cases. Gonorrhœa and other diseases of the generative organs have been repeatedly mentioned in this connection, although their occurrence in the history of many cases cannot be regarded as of any real significance. The disease is somewhat more frequent in the poor, especially in those who suffer from malnutrition and anæmia. Hadden[24] attributes it in part to too exclusive use of amylaceous and saccharine food.

Tuberculous history or infection has been frequently referred to, but it must be admitted that tuberculosis usually develops in early life and carries off its victim before he reaches the age of greatest liability to this affection. It is also difficult to estimate the etiological importance of a disease so prevalent. Influenza and other acute infections seem at times to exert an unmistakable influence on the induction of the disease.

Some authors look upon the most chronic form of monarthritis deformans occurring in the hip (morbus coxæ senilis), especially in the very aged, as merely a result of senile change in the joint.

There are two principal theories in regard to the etiology: First, that the disease is of nervous origin, and, second, that it is a chronic infection. The former of these theories, suggested by Mitchell, is well supported by clinical facts, chief among which are: (1) the symmetrical distribution of the joint lesions; (2) the similarity of these lesions to those occurring in locomotor ataxia, syringomyelia, and other affections of the spinal cord; (3) the frequent occurrence, in the course of the disease, of nutritive changes (dystrophies) of the skin, nails, muscles, and bones; and (4) the evident importance of shock, worry, grief, and mental exhaustion in the etiology of some cases.

Unfortunately sufficient post-mortem investigations have not been made to determine the nature of the changes which are supposed to exist in the nervous system. Falli[25] reports two autopsies on typical cases in which he found atrophy of the anterior horns of the spinal cord, and also, in one of the cases, degenerative changes. Neuritis has been demonstrated in several cases, but, as Osler[26] remarks, it is doubtful whether the change is primary or secondary. Ord compares the disproportionate atrophy of muscles to that of progressive muscular atrophy, and infers from their similarity that the disease may be due to lesions in the trophic centres of the cord or to peripheral irritation. Blake[27] attributes the nerve changes to the absorption of various toxic substances from within or from without, and, in the same way, Bouchard[28] attributes Heberden's nodosities to that form of auto-intoxication which is associated with dilatation of the stomach.

The theory of microbic origin has attracted much atten-

tion, but as yet it lacks substantiation. The following facts lend support to it: 1. Several investigators, among them Schüller,[29] Bannatyne,[30] and von Dungern and Schneider,[31] have found micro-organisms in the fluid or tissues of the joint. 2. The disease sometimes begins with an acute onset corresponding in clinical aspect to that of an acute infection. 3. It frequently follows more or less closely upon an infection, as gonorrhœa, puerperal sepsis, influenza, or an acute exanthem. 4. Enlargement of the spleen and lymph glands has been noted in some of the cases reported as occurring in children. Schüller does not, however, look upon the bacteria in the joints as being more than indirectly the cause of the disease, possibly in some manner preparing the joint for the deposit of lime salts.

MORBID ANATOMY.—The pathological process involves primarily the articular cartilages, the synovial membranes, and the bones. The disease usually advances symmetrically, so that the lesions in one articulation correspond closely to those in the corresponding joint of the opposite extremity. Later in its course changes occur also in the capsular and other ligaments, in the periosteum, and in the muscles; and to complete the picture we must include the lesions in the nervous system to which reference has been made.

In the articular cartilages the process begins in the centre, the area farthest removed from blood supply and most subjected to friction. It is described by Cornil and Ranvier[32] as a multiplication of cells throughout the entire thickness of the cartilage and the formation around them of capsules resembling cartilage cells, but incapable of deep staining with iodine. Similar secondary capsules develop within these. The cartilage then becomes fibrillated upon the surface by the rupture of the most superficial capsules into the joint cavity and by the formation of parallel tubules from the rupture of the deeper-lying capsules one into another. The degenerated cartilage is finally removed by friction, aided, no doubt, by mucoid degeneration (Rindfleisch) and absorption, exposing the underlying bone over a gradually increasing area. Around this a process of new formation takes place not unlike that so often seen in caries. Cell proliferation continues, forming nodular masses which ossify and constitute the chief element in the production of deformity and the limitation of motion. Sometimes, instead of the nodular growth, a more or less complete bony ring is formed, producing the condition known as "lipping." As a result of either process the end of the bone often appears to be much enlarged. In the spinal column the overhanging edges frequently blend and firmly weld the vertebræ together (spondylitis deformans).

The exposed surfaces of the bone undergo hardening (osteosclerosis), and through friction acquire an ivory-like polish. The minute orifices of Haversian canals may be seen in the polished surfaces. While this eburnation is taking place the underlying spongy portion of the bone is undergoing a rarefying ostitis resulting in an osteoporosis. As a result of the latter process, when it reaches the surface, the articular face is often grooved and deformed, even in parts not yet denuded of cartilage. The heads of the humerus and femur have been almost entirely removed in this manner. Warren[33] aptly says that as a result of these various changes, "the head of the bone appears as if it had at one time been composed of a substance capable of softening from heat, and in that condition had been held carelessly while it was allowed to cool." Billroth compares it to "a fluid which had been poured out and stiffened while flowing." These comparisons are especially applicable to the knee and elbow joints. The shafts of the long bones in some cases show enlargement and increased density. The neck of the femur may become bent at a more acute angle to the shaft. Bony ankylosis occurs only in the vertebral column, and there is no tendency to the formation of fibrous adhesions as in other joint affections.

The synovial membranes become highly vascular; their blood-vessels push upward into the cartilages and doubtless assist in their destruction. Some authors look upon this hyperæmia of the synovial membranes as the first step in the morbid process. In the polyarticular type of the disease there is often a pannus-like growth of the membrane over the cartilage (Warren). The membranes are thickened, and their fringes elongated. Their cells proliferate and cartilaginous nodules are formed. These often become freely movable, although still attached by a fibrous pedicle. They are sometimes detached and lie loose in the joint cavity. Adams found no fewer than forty-five of these "foreign bodies" in one elbow joint; as many as four hundred have since been noted in a single articulation. They are usually small and round, but sometimes attain the size and shape of chestnuts. They rarely ossify and probably sometimes unite, having the appearance of being glued together. Fatty tissue also is frequently found in the folds and fringes of the synovial membranes. The synovial fluid, often increased in the beginning of the disease, is generally diminished in the later stages, and the joint becomes abnormally "dry." Mucin has been found in excess in the synovia; sodium urate is never present. Schüller has repeatedly found lime salts, especially the crystalline oxalate, in the cartilages and synovial membranes. Suppuration occurs only as a result of operative interference or exploratory puncture.

The bursæ in the vicinity of the affected joints are often distended by effusion, sometimes forming cysts. These were first described by Morrant Baker.[34] They form a bulging which imparts a doughy sensation on palpation at the sides of the articulation or elsewhere. The fluid is at first confined to the joint, but later, according to Baker, with the increase of tension, it escapes through channels of normal communication into the bursæ; or it may form a hernia of the synovial membrane. If the tension within the sac becomes too great, it ultimately escapes into a cavity bounded by the muscles and other tissues.

The muscles appear wasted and of a brownish color. Spender[35] says that the phenomena of muscular atrophy are myelopathic and capable of definition as a strict spinal paralysis. They at least correspond to the type which is met with as a result of nervous lesions, some bundles showing greater degenerative changes than others. Some of them in fact are entirely replaced by connective tissue. "The muscles perish, fibre by fibre."

The ligaments, periosteum, and tendons not infrequently undergo marked thickening in proximity to the diseased joints.

SYMPTOMS.—Following the classification of Charcot, the symptomatology is to be considered under three heads corresponding to a like number of types of the disease. Clinically these varieties have comparatively little in common. They are the multiple or progressive form, the monarticular form, and Heberden's nodosities.

1. The multiple, progressive type may be again subdivided into an acute and a chronic form, to which some add another (subacute) form, differing only in degree.

The acute form occurs more frequently than do any of the others in subjects under forty. It is readily mistaken for subacute rheumatism, but it is rarely so severe as to suggest the acute type of that disease. There is ordinarily enlargement of the joints from the beginning, yet the suffering is not so severe as to confine the patient to bed. When the onset is very acute, however, the pain may be beyond all comparison to the swelling. The skin is not usually reddened. The disease is symmetrical in its manifestations or soon becomes so; the small joints, as those of the fingers and toes, are oftenest affected. It does not migrate but continues to affect the articulations first involved, while others, often larger joints, become similarly affected. Its progress is generally in a centripetal direction. Elevation of temperature rarely exceeds 102° F. Headache, malaise, and anorexia are now and then complained of, and the patient nearly always appears anæmic. There is no tendency toward involvement of the heart. After a time the acute symptoms subside only to recur again at uncertain intervals and

with variable force, often apparently as a result of exposure, injury, or an indiscretion in diet.

The chronic form of the multiple arthritis deformans is much more frequent than the acute and it is more insidious in its onset. It frequently begins in a single joint of a finger or toe, the corresponding articulation of the opposite member soon becoming affected. The middle finger is not seldom the first to be attacked. The disease then extends in a centripetal direction, ultimately involving nearly every joint in the body, including the temporo-maxillary, the vertebral, and occasionally the sterno-clavicular. The carpo-phalangeal articulations of the thumbs often escape.

The patient first notices a stiffness of the joints, especially in the morning. They are painful and are tender on pressure. As in the acute type, the progress is not constant, intervals of apparent rest sometimes extending over weeks, months, and even years. Each exacerbation renders the deformity a little more pronounced and the joint movement a little more restricted. Pain, seldom much noticed during the intervals, is not always severe in the acute stages, but it may be distressing. It is usually less severe in advanced cases. In addition to the joint pains the patient sometimes suffers from others of a neuralgic character, particularly in the ball of the thumb or the inner side of the wrist, and from bone pains. Neuralgic pains are supposed to be most severe and most persistent when due to trophic degeneration of nerve roots. Fever occurs only in the more acute exacerbations. The pulse is accelerated; its tension is variable, but it is as a rule lower than in gout or rheumatism. Numbness and tingling of the hands and feet are in some instances early symptoms, even preceding other manifestations, as noted by Homolle[36] and Howard.[37] Free sweating is less frequent than in rheumatism, but Anders[38] has observed it in advanced cases, and Spender regards localized perspiration, especially of the fingers, an early symptom. As a result of trophic changes the skin becomes pale, dry, smooth, and glossy, sometimes irregularly pigmented (freckled) over the affected joints. Spender notes cutaneous pigmentation on various other parts of the body. Onychia may occur: Anders has seen three cases. Bedsores occur only very rarely.

Muscular atrophy is a prominent feature of all advanced cases; it is more profound than that which results merely from disuse. It affects both sets of muscles, but the extensors to a higher degree than the flexors. The joints are usually flexed unless this is prevented by the encroachment of the osteophytic formations. Gowers[39] calls attention to increased myotatic irritability with normal or lowered electrical irritability as a common symptom. He therefore attributes the atrophy to changes in the terminations of the pyramidal fibres in the gray matter. Sudden spasmodic or tonic, painful contractions of the muscles occur in some cases and for the time greatly aggravate the joint pains. Such contractions are exceedingly distressing to the patient when they occur in the muscles of the jaw in connection with arthritis of the temporo-maxillary articulation, often seriously interfering with the taking of food. The reflexes over the affected joint may be increased or diminished, or they may remain normal so far as they can be tested.

Crepitus of a peculiar character, cracking, creaking, or grating, is one of the earliest symptoms. In advanced cases, a sound is sometimes produced by movement of the affected joints which may be heard at some distance.

Chronic laryngitis is met with in some cases and is regarded by some writers as due to disease of the cartilages of the larynx similar to that in the joints.

Deafness has been known to result from involvement of the small bones of the ear.

Asthma occurring in connection with the disease, as noted by several authors, can hardly be regarded as more than an accidental complication.

2. The monarticular type. There is much ambiguity in the use of the word monarticular in this connection, since it is applied to a type of the disease which does not always confine itself to a single joint. It is in many cases only the predominance of the manifestations on the part of one of the larger articulations that justifies the use of the term. The points of difference between this and the multiple type are very striking. It occurs more frequently in men than in women, notably in those over fifty years of age. It attacks by preference the larger articulations, especially the knee, shoulder, elbow, and hip. It confines itself as a rule to the articulation first affected, but the opposite joint sometimes becomes involved to a less degree. The vertebral column is often attacked (spondylitis deformans), few or many articulations, rarely a single one, being involved, and this occurs alone or along with involvement of other joints, especially the shoulder or hip. The entire column becomes rigid in extreme cases. When the shoulder or hip is affected, the shortening of the limb keeps pace with the absorption of articular cartilage and bone. In hip-joint cases the shortening may be increased by the bending of the femoral neck, still more by the dislocation of the head of the bone, favored by the extensive absorption of the articulating surfaces and aided by muscular contraction. The affected joints not infrequently have the appearance of being subluxated or dislocated, owing to the great deformity, when in reality there is little or no displacement. When fluid accumulates in the joint, in the bursæ, or in adventitious cysts, the deformity is greatly augmented. Movement of the affected joint is attended with the characteristic creaking crepitus. Pain is a prominent symptom, occurring more or less periodically and aggravated by motion. Associated with hip-joint involvement, it not infrequently simulates sciatica in its extension down the thigh and leg.

The buttock and thigh are shrunken from muscular atrophy, and, from the same cause, the appearance of the shoulder resembles that of progressive muscular atrophy. The loss of motion is almost complete; bony anchylosis does not take place, however, except between the vertebræ. The knee jerk is exaggerated on the affected side. The patient is unable to cross the diseased leg over the sound one without assisting the movement with the hands (Garrod).

A. E. Garrod refers to a peculiar type of monarthritis deformans which is limited to the carpo-phalangeal articulations of the thumbs, joints which are most frequently immune to the polyarticular form of the disease. It is generally attributable to undue exercise of these joints incident to the occupation of the individual, and may be readily recognized by the enlargement and the characteristic crepitus.

Heberden's nodes are sometimes associated with this type of the disease.

3. Heberden's nodosities are small, immovable exostoses, "little hard knobs," which develop on either side of the distal joints of the fingers, arising from the small tubercles at either side of the dorsal surface of the second phalanx. In the joint proper the characteristic destruction of cartilage and eburnation occur. The disease is more frequent in women than in men; it comes on, as a rule, between the thirtieth and the fortieth years of age. The nodosities usually constitute its only manifestation in the case, unless it be associated with the monarticular form. They at times develop in gouty subjects, but are entirely independent of that disease and distinct from tophi. Sodium urate is not found in the joint fluid. The joints are often swollen, slightly reddened, and sensitive to pressure in the early stages of the disease, but later they occasion little inconvenience aside from stiffness and deformity. Heberden described the nodes as of the size of a pea; they may, however, exceed that size. In some cases the enlargement is fusiform, a doughy mass forming around the joints. The disease follows the same intermittent course that characterizes the multiple type, acute attacks being induced by injury, or apparently by errors in diet. The finger tips may be deflected toward the radial side as in the ordinary type of the disease. The thumbs generally escape. Charcot calls at-

tention to the frequent occurrence of cancer in women affected with the nodosities.

Arthritis Deformans in Children.—The disease is not of frequent occurrence in children. Koplik, in 1896, was able to find but eighteen recorded cases, and Garrod has shown that all cases which on account of their clinical features are classed as such are not truly of that nature. Schüller[40] goes yet further and expresses the conviction that all the cases that have been described as occurring in children are examples of polyarthritis chronica villosa recently described by him. The pathological conditions of the joints in three fatal cases reported by Still[41] undoubtedly conform more closely to the latter disease than to arthritis deformans, the articular cartilages showing no destructive change, and the clinical manifestations are so much at variance with those seen in adults as to leave ample room to doubt the occurrence of true arthritis deformans in childhood.

The onset is generally acute, sometimes with fever and chill, and it almost always begins before the second dentition. Girls are oftener affected than boys, but in a lower ratio than is the rule in adult life. Swelling of the joints with stiffness and some tenderness is the rule. Exacerbations are frequent. Such complications as dystrophies of the skin and nails are infrequent. The enlargement of the joints appears to be due to a general thickening of the soft parts rather than to exostoses, but the limitation of motion may be extreme. General enlargement of the lymph nodes and spleen has been pointed out by Still, who also observed pericardial adhesions. The children generally show lack of development. Spender and Diamantberger have reported its association with exophthalmic goitre, also an infrequent disease of childhood, and Still notes a prominence of the eyes in all his cases.

Character of the Deformities.—The deformities of the hands and feet are quite characteristic of the disease. The changes in the metacarpo-phalangeal articulations cause the fingers to turn toward the ulnar side. At the same time the fingers are often flexed strongly upon the palm and usually overlap one another. There may be also a bending of the distal extremities toward the radial side. These changes along with the wasting of the interossei muscles give the hand a claw-like appearance, resembling that of progressive muscular atrophy.

Most of the joints are firmly locked, but they may be abnormally movable and easily dislocated. A ball-and-socket joint is sometimes formed and other peculiarities are occasionally met with. In some cases a fusiform enlargement occurs, as a result in great measure of the thickening of the soft structures about the articulation, which gives the joint the appearance of being surrounded by plastic matter.

The feet are, as a rule, extended to the fullest degree, and the joints are even more rigid than are those of the hands. The toes are turned outward and overlap, the great toes being involved with the rest.

The deformity of the large joints consists chiefly in a widening of the articulation by the osteophytic growths and the lipping of the ends of the bones. The appearance is often that of fluid distention, but palpation readily reveals the presence of bony excrescences sometimes covered only by the integument and apparently sharp enough to cut their way through it. The greatest prominence is on a level with the articular surfaces, as a rule. Fluid distention does occur, especially in recent cases, but the appearance is not materially different from that due to osteophytic enlargement unless the adjacent bursæ become involved. The dorsum of the wrist is a favorite seat of bursal distention. Adventitious cysts may cause swelling at some distance from the affected joint. A fusiform enlargement like that which occurs in the fingers is at times seen about larger articulations, particularly the wrist, entirely destroying the normal contour of the joint.

As a result of the changes in the hip and knee and coincident muscular contraction, the legs are closely flexed upon the thighs and the thighs are partially drawn up; or the limb may be rigidly extended. Involvement of the shoulder and elbow leads to similarly rigid abnormal positions of the arms. Thompson[42] has demonstrated that the rigidity of the joints is not to any extent overcome by anæsthesia. The enlargement and deformity are rendered all the more apparent by the wasting of the muscles about them.

The results of spondylitis are exceedingly distressing to the patient, for it is in the spinal column that we meet with the most pronounced bony ankylosis. All motion is lost in extreme cases. When the cervical spine is affected the head is sometimes drawn to one side and its rotation may be prevented. The patient loses his upright bearing and must maintain his equilibrium with a cane. The osteophytic growths can sometimes be felt; they occasionally impinge upon nerve roots causing radiating pains and causalgia.

The Blood.—Sufficient attention has not been given to the investigation of the blood and other fluids. Bannatyne[43] found the hæmoglobin generally deficient, with slight diminution of the red corpuscles and slight increase of the white. He did not find microcytes or nucleated cells. Cabot[44] reports five cases in which the blood was normal except for a slight deficiency in the hæmoglobin of two cases.

The Urine.—Albuminuria has seldom been noted except in the aged, in whom its occurrence cannot be attributed to the arthritis. Von Noorden[45] and Rumpf[46] have observed a diminution of the salts of lime and magnesia and of phosphoric acid; the former observer noted a like diminution of the same ingredients in the fæces. Schüller has also noted a deficiency of lime salts and of the earthy phosphates, a low specific gravity, and a neutral or alkaline reaction in most cases; his investigations extended over many years.

Diagnosis.—It is often difficult, if not quite impossible, to differentiate arthritis deformans of either type from corresponding rheumatic affections until comparatively late in the course of the disease. In the acute cases, however, suspicion should be aroused by the symmetrical involvement of the small articulations alone and by the stationary character of the affection, especially if it appear in a woman whose age and history render the disease of probable occurrence. Involvement of the endocardium in a measure contraindicates the disease. Persistent joint enlargement after the first acute symptoms have subsided is almost pathognomonic.

Chronic rheumatism does not as a rule involve so many joints, is more likely to be unilateral, and does not so often attack the temporo-maxillary articulation. Neither form of rheumatism produces the creaking crepitus, the characteristic deformities, or the degree of immobility which pertain to this disease.

Gonorrhœal rheumatism may resemble arthritis deformans in its tendency to involve the larger joints and to remain localized. It is to be recognized for the most part by the history of a previous urethritis, by the absence of osteophytic growths, and by a tendency to an increase of the joint fluid, rather than a diminution of it, in even the most chronic cases.

From chronic gout this disease is distinguished by the symmetry of the lesions, by the involvement of many small joints instead of a single one, by less pain, by the absence of tophi, by the enlargement of the ends of the bones, and by the absence of a pronounced hereditary tendency. Arterioscleroses occur in arthritis deformans only as senile changes.

The shoulder joint is sometimes affected by a localized arthritis, which may bear clinical resemblance to this disease. Several such cases are referred to by Anders and by Osler. It affects, however, only the capsular and other ligaments of the joint; the wasting of muscles is confined to those attached to the "shoulder girdle," and recovery from it is complete.

Progressive muscular atrophy may be differentiated by the absence from it of any affection of the articulation.

Sciatica rarely arouses suspicion of arthritis. It may be excluded by the extension of the pain to the dorsum of the foot, by the absence of tenderness in the joint, and

by the ability of the patient to cross the affected leg over the sound one while sitting; but sciatic pain sometimes occurs in arthritis deformans.

Charcot's Disease.—The joint lesions which sometimes occur in connection with locomotor ataxia are difficult of differentiation only when they occur early in the disease, before the pathognomonic symptoms of the ataxia have developed. They may generally be excluded by the presence of inco-ordination and other symptoms of ataxia, by their sudden onset, and by the more rapid, painless, progress of the joint affection. Neither is the osteophytic growth so great, as a rule; the changes are atrophic rather than hypertrophic.

Joint lesions clinically resembling those of arthritis deformans are at times met with in syringomyelia. The latter disease, however, is oftener seen in early life, and it exhibits disturbances of sensation and other manifestations typical of spinal-cord disease.

Hæmophilia sometimes presents joint lesions, but they, too, are more frequently encountered in early life. Bowlby[47] has shown that there is an effusion of blood into the joint, often but not necessarily a result of injury, and that fibrous adhesions are formed between the cartilaginous surfaces.

The deformity of the hip occurring in coxa vara is clinically identical with that of arthritis deformans, in some cases at least. Maydl[48] says it cannot be differentiated without operation and inspection of the joint. Fortunately the disease occurs only in young subjects at or before puberty.

Polyarthritis Chronica Villosa.—Under this name Schüller[40] has recently described a joint disease clinically resembling deforming arthritis. It is most frequent in females before the menopause and may occur in childhood. The pathological lesions are confined to the synovial membrane; they may continue for a decade without destruction of cartilage, although they may produce deformity and restriction of motion amounting to ankylosis. Pain is a prominent symptom and its occurrence is largely independent of movements of the joint. A monarticular form occurs, but it is much less frequent than monarthritis deformans. Schüller finds a bacillus which differs from that found by him in this disease.

Maclagan and Barlow[49] refer to a "spurious arthritis" in which the symptoms are like those of arthritis deformans, the former describing it as a result of injury, the latter as occurring in alcoholic neuritis.

PROGNOSIS.—Arthritis deformans is incurable. Much may nevertheless be done in the early stages to check its progress and during the acute exacerbations to relieve suffering. It is not directly dangerous to life. The patients may live to old age in comparatively good health, if death does not occur from some intercurrent malady. The progress of the disease usually becomes slower as it advances and the suffering becomes less intense, although its victim may become bedridden from weakness and deformity. Through this disability it predisposes the patient to many affections that are apt to hasten his death.

TREATMENT.—The treatment is that of a slowly debilitating disease. The patient is below par and every effort should be made to improve the general condition and to correct such concomitant defects as may exist in the action of organs. The abstraction of blood and the administration of debilitating drugs are alike to be avoided. Our most potent and the safest agencies withal are found in hygienic and dietetic measures.

All authors agree that if the patient lives in a vitiated atmosphere, especially if he occupies damp apartments, he should be removed to more salubrious surroundings where there is an abundance of fresh air and sunshine, and that all worry and care should be taken from his mind; but, unfortunately, these requirements are quite beyond the reach of a majority of the cases. A mere change of air and scenery is often beneficial, and residence in a warm climate, where the atmosphere is dry, not too near the seashore, is highly recommended. Every precaution must be taken against exposure and chilling of the body. Woollen garments should be worn next the skin the year round. The hands and feet when affected must be well protected from cold. The bare feet should never be allowed to come in contact with even a carpeted floor.

The diet should be liberal and of the most nourishing quality; it should include an abundance of nitrogenous food, beef, mutton, poultry, eggs, milk and cream, with a plentiful allowance of vegetables and fresh fruits. Malt liquors may be taken with the meals. Cod-liver oil alone or in combination with malt extract has proved of great service in improving the nutrition of the patients, and should be taken regularly after meals during the winter season. The digestion should always be a subject of care.

During warm weather the patient should spend much of his time in the open air and he should take as much light exercise as is judicious. Even the affected joints ought not to be allowed complete rest, but they should never be exercised to the point of fatigue or pain. Passive motion is safer when the joints are painful. Walking is apt to hasten the progress of the disease in the hip or knee.

Many methods of local treatment have been employed and some of them have been lauded as curative; but local measures can only modify local conditions. They do not remove the cause, and improvement induced by them is apt to prove but transitory.

Thermal baths have been of much benefit in some cases, but are regarded as harmful by several authorities. Garrod says: "It would seem that in this disease the mode in which the water is employed is of more importance than the chemical composition, but at several of the places at which the most satisfactory results are obtained the waters are of the sulphurous class." He has found that the most effectual line of treatment is that which consists in massage combined with douching without the actual immersion of the patient. Suitable places for the application of this treatment may be found in all parts of the world. In Europe, Aix-les-Bains and Aachen (Aix-la-Chapelle) bear the highest repute; in England, Bath and Harrogate. In the United States sulphur springs are numerous and many places are equipped with suitable arrangements for properly carrying out the treatment. The springs bearing the highest repute are the hot sulphur springs of Virginia, the Hot Springs of Arkansas, and Glenwood Springs, Colorado. General vapor baths afford temporary relief. They should be taken immediately before retiring and not at too frequent intervals. Local vapor baths applied to the affected joints have been found safer and more beneficial. Electric baths have been applied in various ways, but the results have not been encouraging.

When these methods are inconvenient or beyond the means of the patient, equally good results may usually be obtained from hot fomentations and other methods of home treatment. Relief of pain may be obtained from the immersion of the joints once or twice daily for ten minutes in water as hot as can be borne. Hot water applied in a stream from a small orifice with considerable force is more quickly stimulating and produces an agreeable sensation. Schüller and Baruch[50] recommend the Scotch douche in which an alternating stream of hot and cold water under varying pressure is applied. Baruch follows this with the application of wet compresses. The application of moist heat should be accompanied by massage of the muscles. The Swedish movement is also beneficial. Following massage, belladonna ointment may be applied if the joints are painful, or a mixture of equal parts of guaiacol and glycerin may be rubbed in. The application of ichthyol in alcohol and ether or by inunction in vasogen (ten to twenty per cent.) is highly recommended by Edlefsen,[51] who finds that it not only relieves the pain, but also contributes to the restoration of mobility. After this treatment the joint should be wrapped in cotton and covered with oiled silk. Complete rest may be secured by allowing the limb to rest on a splint. Strümpell recommends the application of

hot sand, a method used by Haygarth. None of these methods can be relied upon, however, unless they are thoroughly carried out; half-way measures are more likely to do harm than good.

The hot-air treatment has been much resorted to of late and has yielded excellent results in some cases. It is applied by means of an apparatus devised for the purpose. This consists of an asbestos-lined cylinder which is provided with a lamp to heat the air and a thermometer. The joint to be treated is loosely but closely wrapped in a Turkish towel and thrust into the cylinder, where it rests on a hammock-like support. A canvas sleeve attached to the cylinder is drawn close around the limb to prevent the escape of heat. The lamp is then lighted and allowed to burn until the thermometer registers from 250° to 300° F., when it is regulated to maintain the temperature for from a half-hour to an hour. This should be followed by passive motion of the joint and massage of the muscles. The treatment is to be repeated at intervals varying from a half-day to several days, according to the condition of the patient and the effects produced. Lindemann [52] has recently invented an apparatus for this treatment, which he calls an "Elektrotherm." The heat is produced by electricity and may be applied to the entire body or to any part of it. From its use he reports excellent results in deformative arthritis of long standing.

Whatever benefit is obtained from the hot-air treatment is doubtless due to its effect upon the circulation of the part, the chief element of which is probably a persistent dilatation of the blood-vessels. On account of the possible disturbance of the general circulation and the elevation of the general temperature, the duration of the treatment should be carefully regulated to suit the physical condition of the patient. All local measures should be employed with caution in the presence of acute symptoms; they may be applied with more vigor in advanced cases.

The application of electricity is considered beneficial by some authorities but useless by others. The faradic current may be used for its action on the muscles and the galvanic for its effects on the nervous system. When the latter is applied, a mild current with slow interruption should be passed through the affected nerve trunks, through the nape of the neck, and through the dorsal region. Static electricity has also been employed in various ways. Morton [53] claims that the high potential high frequency current will arrest the progress of the disease at any stage, the result being secured more slowly in proportion as the disease is more advanced. He recently exhibited skiagraphs to demonstrate the benefits of treatment by what he calls the "electric wave" current.

Internal medication is of little benefit except in the early stage of the disease or during acute exacerbations. Anodynes are then sometimes necessary, opiates should be avoided if possible. Chloral, highly recommended by some writers for the relief of pain, is also objectionable on account of the possible development of a habit. The salicylate of soda is effective in the relief of acute symptoms in some cases, but it is liable to do harm if too continuously administered. It is the custom of many physicians to administer iodine or one of its compounds, and by many authors this is regarded as the most beneficial of all remedies, but the results obtained by others have not been uniformly satisfactory. The syrup of the iodide of iron is probably the best means of administering it, since the iron exerts an influence upon the anæmia that is usually present. It is of especial value in the arthritis of children. It may be advantageously combined with arsenic in the form of liquor sodii arseniatis. The tincture of iodine is preferred by some authorities and many instances of marked benefit have been reported from the use of arsenic alone.

Other remedies have been vaunted for a time or by individual observers, but they have failed to stand the test of time. Even Brown-Séquard's elixir was resorted to with supposed benefit, and it is not surprising that the ovarian extract has recently been recommended.

Whatever the treatment adopted in a given case, one fact should be borne in mind, namely, that not days nor weeks, but months, must elapse before a verdict can be pronounced upon its results. *James M. French.*

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ARTHROLOGY.—That part of anatomy which treats of the joints or connections between the denser parts of the skeleton. By means of these joints, or articulations, the skeleton, originally an apparatus for support, becomes an apparatus for locomotion. In its primitive condition the human skeleton is without joints, being represented, in the human fœtus before the fifteenth day, by a simple non-jointed rod of condensed embryonic tissue called the notochord, a form permanent in the lowest vertebrate (amphioxus). This becomes ensheathed with tissue, which is the matrix of the more complex skeleton (Fig. 329). The substance of this sheath changes to cartilage at regular intervals, thus becoming segmented (Fig. 330). Vestiges of the notochord are found in the adult as pulpy masses within the discs

which unite the vertebræ. Elsewhere in the human body joints are formed in a similar way. Rods are laid down and then segmented by the differentiation of certain portions into cartilage, which may afterward ossify. The structures by which union is effected at the joints may, therefore, be considered as the altered remains of the original skeletal matrix. Around the segments this matrix remains as fibrous tissue, termed the perichondrium, becoming periosteum, when ossification ensues,

FIGS. 329 and 330.—Formation of Primitive Joints.

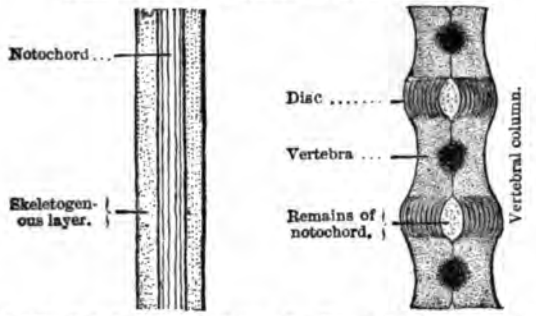


FIG. 329.—Notochord without Joints. (Fœtus fifteen days.) FIG. 330.—Joints Derived from It. (Child at birth.)

and between the segments it occurs as similar fibrous tissue, changing to fibro-cartilage in certain cases. When in the form of bands, straps, or membranous sheets, these transegmental structures are termed ligaments. They may unite not only the apposed ends of segments, but also the related sides. Sheets of this sort passing laterally from one bone to another in the same plane are known as interosseous membranes. Examples are seen between the radius and ulna, and between the tibia and fibula. The entire ligamentous system is closely connected with the fasciæ, of which it may be considered a specialization (see *Fascia*).

The prime characteristic of joints is, therefore, the movements which become possible by reason of segmentation. These movements vary according to the varying functions of the segmented members, and thus produce corresponding modifications of structure in the parts composing the joint. Upon these modifications the classification of joints depends. In all joints there is originally sufficient intersegmental tissue to permit slight and limited motion. Such are called primitive or amphiarthrodial joints. Examples occur in the adult between the bodies of the vertebræ (Fig. 330). In the course of development the osseous or cartilaginous tissue of the segments usually tends to encroach more and more upon the intersegmental structure. If no alteration occurs in this, the joint becomes less and less movable until complete fixation ensues. It is then termed synarthrodial or immovable. Examples are seen in the adult skull. The process may be carried so far as wholly to obliterate

FIGS. 331 and 332.—Synarthrodial Joints.

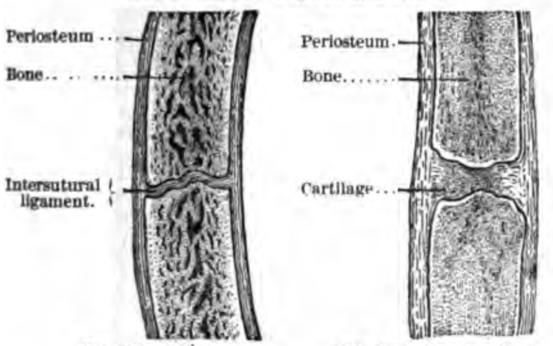


FIG. 331.—Suture. FIG. 332.—Synchondrosis.

the joint. When the connecting substance is fibrous, the joint is termed a suture (Fig. 331); when cartilaginous, a synchondrosis (Fig. 332). Strictly speaking, the union of the shaft of a long bone with its epiphysis is a synchondrosis. There being no strain caused by movement in this class of joints, the periosteum passes over the intersegmental tissue without thickening into ligamentous structures.

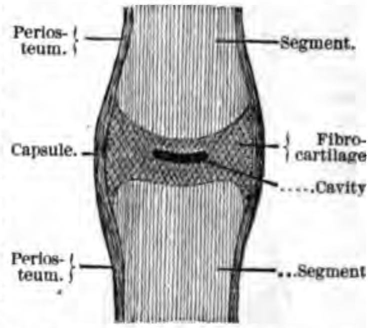


FIG. 333.—Formation of Synovial Cavity.

In by far the greater number of cases the intersegmental tissue becomes altered. Between certain of the cells, vacuoles or small cavities form (probably by the enlargement of the lymph lacunæ of the connective tissue), and these join together, making a larger cavity or cleft. The cells immediately around the cavity form a secreting surface, the synovial membrane, the product of secretion being a glairy fluid called synovia. The membrane resembles the similarly formed serous membranes of the body, as well in structure as in great vascularity, and in liability to sudden and dangerous inflammations. Synovial cavities are formed not only between the apposed segments of a joint (Fig. 333), but also where tendons rub over hard surfaces, or where the skin is closely applied to such surfaces and friction is frequent (see *Bursæ*). Small and imperfect synovial cavities exist in a few amphiarthrodial joints, but usually the joints where they occur are freely movable throughout their extent, and are, therefore, called diarthrodial. The intersegmental tissue may not be wholly obliterated by the cavity. When the movement of the segments is perfectly regular and small in amount, it may remain as a central band with a cavity on each side and ligamentous structures surrounding the whole, forming a capsule or envelope. This is a peculiarity of the articulation of the heads of the ribs with the spine (Fig. 334). When the movement is such that the articular surfaces do not correspond, a synovial cavity is sometimes formed along the surface of each segment, leaving an intervening disc of fibrous tissue, which becomes partly cartilaginous and is then known as an interarticu-

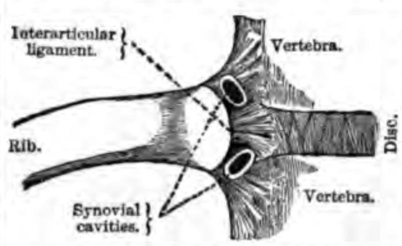
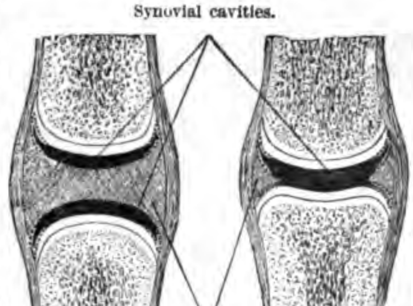


FIG. 334.—Costo-Vertebral Joint.

Synovial cavities.



Interarticular cartilages.

FIG. 335.—Formation of Arthrodial Joints.

lar fibro-cartilage (Fig. 335). Example, lower jaw joint. The disc may become thinned and disappear in the centre, leaving a ring (Fig. 335 shows this in vertical section). This occurs in the knee joint. Its complete disappearance is shown in Fig. 336.

Joints may be formed under pathological conditions, the process being similar to that just described. After fracture the ends of the bone are first united by fibrous tissue, constituting an amphiarthrodial joint, which may remain permanently, or by process of repair be converted into synarthrodial and finally disappear; or, if mobility of the apposed ends be not restrained, there may be developed a false arthrodial joint with synovial membrane and ligaments formed from the surrounding connective tissue.

FIG. 336.—Fully Developed Arthrodial Joint.

The action and relations of muscles are important factors in shaping and otherwise modifying joints. By surrounding they afford protection, and also actively assist the ligaments in holding together the apposed ends of the segments; differing in this, that their tension can

FIG. 337.—A Sesamoid (Knee Joint).

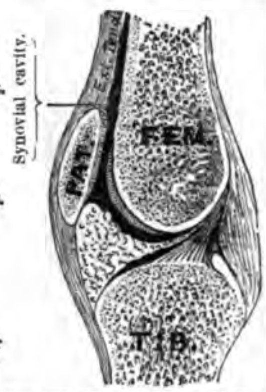


FIG. 338.—Planiform or Gliding Joint (Patello-Femoral). Sliding and coaptative motion only.

be adjusted to the stress placed on the segments. They are invariably attached so as to support the articular surfaces with reference to each other, never pulling

FIGS. 339 and 340.—Pivot Joint (Atlo-Axoid). Rotation only.

FIG. 339.—Top View.

FIG. 340.—Front View.

them apart. Dislocations are therefore more likely to occur if the force is applied suddenly, before the muscles can be put in action, and are rare among professional athletes. Advantage is taken of this peculiarity of the muscles in reducing a dislocation, this being much more easily done when the patient is taken off his guard, or when resolution of muscular force is produced by an anæsthetic. Expansions from the tendons of muscles strengthen and support the joints, uniting with the joint capsule. When the strain put upon these expansions is habitually great, as in case a tendon passes over the angle made by the two segments, the connective

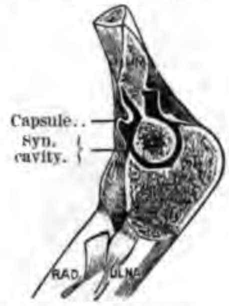


FIG. 341.—Hinge Joint (Elbow). Angular motion in one plane.

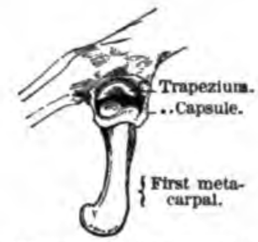


FIG. 342.—Saddle Joint (Thumb). Angular motion freest in two planes.

tissue of the tendinous expansion is liable to take on some denser form, as cartilage or bone. These appear as small nodular bodies known as sesamoids, and possess true articular surfaces. The patella is the largest and most notable example of these (Figs. 337 and 338). The shapes of articular surfaces depend mainly upon the direction and preponderance of the muscular force applied to the segments. The simplest movement possible is the sliding of one nearly plane surface upon another. This is the ordinary movement of the sesamoids. Joints in which this is the prevailing movement are called planiform or arthrodial (Fig. 338). There are, however, no articular surfaces that are perfectly plane, there being no situation where a pulling force is applied in a continuous straight line throughout the extent of the movement. For this reason there is also found in planiform joints a slight rolling of convex surfaces on each other. This is called coaptation. When the surfaces are markedly curved a variety of movements may take place. Motion around an axis passing longitudinally through one of the segments is called rotation. Pivot joints (trochoides) possess only this movement, and are exemplified in the atlo-axoid and superior radio-ulnar articulations (Figs. 339 and 340). Bending the segments so as to alter the angle they make with each other is called angular movement. When lateral,

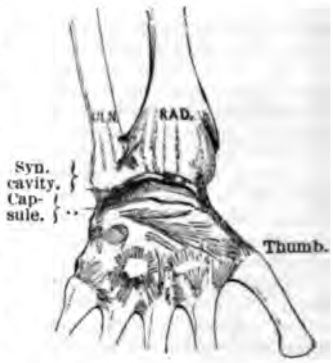


FIG. 343.—Pommel Joint (Wrist). Angular motion in all planes.

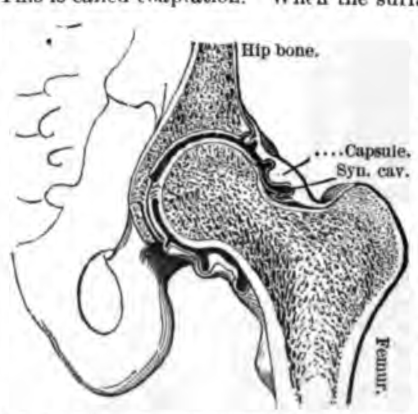


FIG. 344.—Ball-and-Socket Joint (Hip). All movements.

to or from the axis of the body or limb, it is further distinguished as adduction and abduction; when forward or backward, folding or unfolding the segments, as flexion and extension. A hinge joint (ginglymus) is one in which such motion is allowed in a single plane only. The elbow is the best example (Fig. 341). The shape of the surfaces may allow free angular movement in some directions while limiting it to some extent in others. In the saddle joint (Fig. 342), and the pommel joint (Fig. 343), the motion is freest in two planes at right angles to each other. In the former, each surface is convex in one plane and concave in the other; in the latter, the surfaces are reciprocally ellipsoidal. These two classes of joints allow all movements except rotation, it being possible to perform circumduction or such swinging of the distal segment through a series of angular positions as to make it generate a conical surface. When the joint consists of a head nearly spherical received into a closely fitting cavity, it is known as a ball-and-socket joint (Fig. 344), in which great freedom of motion is allowed, all movements being possible.

The following table shows how joints may be classified according to a genetic system:

Costo-vertebral (costo-central).
Costo-vertebral (costo transverse).
Chondro-sternal, second to seventh ribs.
Interchondral, sixth to ninth costal cartilages.
Sterno-clavicular.
Acromio-clavicular.
Radio-ulnar, inferior.
Carpal—between single bones.
Carpo-metacarpal, except thumb.
Intermetacarpal.
Patello-femoral.
Tibio-fibular, superior and inferior.
Tarsal, except astragalo-scaphoid and calcaneo-cuboid.
Tarso-metatarsal.
Intermetatarsal.

Class 2.—*Pivot Joints, or Trochoides.*
Atlanto-axial.
Radio-ulnar, superior.

Class 3.—*Hinge Joints, or Ginglymi.*
Elbow joint (humero-cubital).
Phalangeal, of hand.

CLASSIFICATION OF JOINTS.

PRIMITIVE JOINTS (AMPHIARTHROSES).

- Without Synovial Cavity.
  - IMMOVABLE JOINTS (SYNARTHROSES).
    - United by cartilage. SYNCHONDROSES.
    - United by connective tissue. SUTURÆ.
- With Synovial Cavity.
  - FREELY MOVABLE JOINTS (DIARTHROSES).
    - Motion sliding or coaptative, surfaces nearly flat. PLANIFORM.
    - Motion curvilinear, surfaces curved. NON-PLANIFORM.
      - Rotation only. PIVOT JOINTS.
      - Angular motion one plane. HINGE JOINTS.
      - Angular motion freest in two planes. SADDLE JOINTS.
      - Angular motion all planes. POMMEL JOINTS.
      - All movements. BALL-AND-SOCKET JOINTS.

The following is a list of the joints of the human body arranged upon the foregoing principles of classification. As in all natural classification, perfectly clear and sharp distinctions do not exist, many joints being somewhat mixed, blending the characters of two or more classes.

TABLE OF THE JOINTS.

ORDER I.—PRIMITIVE JOINTS, OR AMPHIARTHROSES.

Class 1.—*Without a Synovial Cavity.*
Intervertebral—of bodies.
Lumbo-sacral.
Sacro-coccygeal.
Sternal.

Class 2.—*With an Imperfect Synovial Cavity.*
Sacro-iliac.
Interpubic (symphysis pubis).

ORDER II.—IMMOVABLE JOINTS, OR SYNARTHROSES.

Class 1.—*Sutures.*
Joints between the bones of the skull, except occipito-sphenoid and ethmo-vomerine.

Class 2.—*Synchondroses.*
Occipito-sphenoid.
Ethmo-vomerine.
Chondro-sternal of first rib.
Costo-chrondral.

ORDER III.—MOVABLE JOINTS, OR DIARTHROSES.

Class 1.—*Planiform Joints, or Arthrodia.*
Intervertebral, of articular processes.
Lumbo-sacral, of articular processes

Knee joint (femoro-tibial).
Ankle joint (tibia and fibula with astragalus).
Phalangeal, of foot.

Class 4.—*Saddle Joints.*
Carpo-metacarpal, of thumb.
Calcaneo-cuboid, of ankle.

Class 5.—*Pommel Joints* (*Condyloid*).
Temporo-maxillary.
Occipito-atlantal.
Radio-carpal.
Intracarpal (os magnum with semilunar and scaphoid).

Class 6.—*Ball-and-Socket Joints* (*Enarthrodia*).
Shoulder joint (scapulo-humeral).
Metacarpo-phalangeal.
Hip joint (coxo-femoral).
Tarsal, astragalo-scaphoid.
Metatarso-phalangeal.

An examination of the intimate structure of adult joints involves, (1) the ends of the segments (usually bones); (2) the articular cartilages which protect them; (3) the fibro-cartilages which, when present, adapt the surfaces to each other; (4) the ligaments which prevent their separation; (5) the synovial membranes which by their secretion lubricate the joints.

At joint surfaces pressure and movement occasion a modification in the ordinary structure of bone. The ends are enlarged and the surfaces are of extremely compact tissue, protected by a layer of hyaline cartilage, the remains of the original cartilage from which the bone was formed. Acting as a buffer to break shocks

and to prevent wear, it is invariably thickest where the pressure is greatest (see Fig. 336). Under normal conditions it never ossifies, although in old age and in persons of inactive life it becomes thinned and infiltrated with lime salts. Should it slough, the bone becomes rapidly worn smooth (eburnated) and the joint is disabled. The superficial cells of the cartilage are flattened, but in the deeper parts they multiply in the line of the greatest stress, and are therefore arranged in columns perpendicular to the articular surface (Fig. 345), in which direction a sudden shock may cause the cartilage to split. The fibro-cartilages found in joints are composed of white fibrous tissue, with sparse elastic fibres to impart the necessary resiliency. Their usual form is that of discs or rings attached mainly to the more movable segment, either by their edges (knee, jaw) or by the edge and one surface (hip, shoulder). The rings may be incomplete, enlarging the cavity on one side only (phalanges).

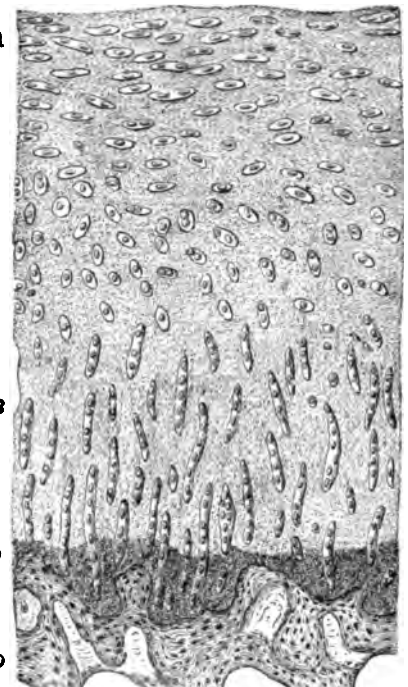


FIG. 345.—Articular Cartilage. (After Sappey.) A, Flattened cells; B, cells in columns; C, region infiltrated with lime; D, bone.

The original capsular arrangement of the ligaments remains in cases in which the joint is well protected by muscles and the strain is evenly distributed. In most joints, however, the stress being much greater in some directions than in others, the capsule becomes thickened to counteract it, forming bands which have received special names. Atmospheric pressure, acting against the force of gravity, assists in keeping the articular surfaces applied to each other, thus preventing a constant strain upon the ligaments. An important office of the ligaments is to limit the motion of the segments and prevent the shocks which would otherwise occur from the sudden contact of bony surfaces. In some cases they greatly economize muscular force by holding the joint in a set position. Thus but little force is required to maintain the body erect, as it is supported mainly by the tension of the ligaments of the spinal column, by the ilio-femoral ligament at the hip, and by the posterior, lateral, and crucial ligaments at the knee; these lying always on the convex side of arcs subtended by the line of the centre of gravity (Fig. 346). Owing to their function as limiters of motion, it follows that the position of greatest relaxation for all the ligaments of a joint is one midway between flexion and extension. In case of the distention of a joint cavity by a morbid effusion, the patient involuntarily places the joint in such a position.

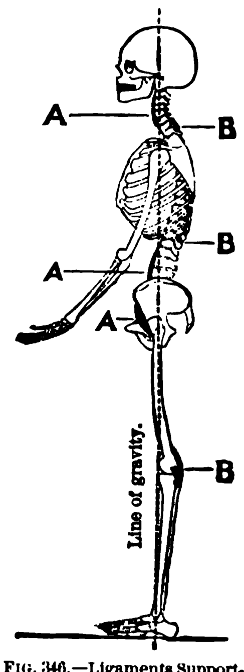


FIG. 346.—Ligaments Supporting Erect Posture. A, Anterior set; B, posterior set.

Synovial membranes originate as continuous and closed sacs, but over the articular surfaces, where pressure occurs, portions of them disappear; so that, at the latter part of fetal life, they merely line the capsule and extend but a short distance upon the cartilages of the joint. In adult age they frequently are further extended by communication with the synovial cavities of neighboring bursæ, and such communications become more frequent and extensive as age advances. They are more lax than the surrounding ligaments, being thrown into folds to increase the blood supply and to pad out intervals, being assisted in this by interstitial deposits of fat. Along the interarticular lines they possess villous processes, or fringes, some of which contain cartilaginous nodules (Fig. 347).

It is at or near the joints that the great vascular trunks divide, an arrangement which is probably connected with the centripetal development of blood-vessels and the bud-like formation of limbs in the embryo. The immediate supply of the joint is obtained from small vessels that anastomose freely with one another. By them the collateral circulation is established when the main trunk is occluded. From these vessels a rich arterial network penetrates the capsule to supply the synovial membrane. Abundant capillaries lie in loops along the synovial folds, and by exudation from them the synovia is formed. The articular cartilages and the compact layer of bone immediately contiguous are normally destitute of vessels, but capillaries rapidly extend into them during inflammation. The fibro-cartilages are stated by Sappey to contain vessels, and may therefore take an active part in inflammatory processes. Lymphatics are numerous near joints. Klein considers the joint cavity itself as a lymph space communicating directly with the lymphatics, and Arnold and Heitzmann claim to have demonstrated a system of lymph canaliculi even in articular cartilage.


FIG. 347.—Synovial Fringes. (× 200.) (Modified from Henle.)

The nerves of joints are distributed mainly to the synovial membrane and the ligamentous structures. It is probable that in these situations special nerve endings exist, as described by Krause and Nicoladoni, for it is difficult otherwise to account for the peculiar sensibility of the structures. A ligament or a synovial membrane may be touched, cut, or pinched without giving much

pain, but if it be stretched beyond its physiological limit, threatening the integrity of the joint, the suffering is excruciating, as is well known to those who have suffered from a sprain or a dislocation. Articular cartilage has no nerves, and the gnawing pain which occurs during its ulceration is probably caused by inflammatory products affecting the nerves of contiguous tissues. A remarkable law of correlation has been noted by Hilton with reference to the nerves of joints, viz.: that they also supply the muscles which move the joint and the skin over the insertion of such muscles; the whole apparatus being thus under the control of associated central influences. There is besides strong clinical evidence of this. Remak and Benedikt have pointed out the strong probability that many diseased conditions of the joints originate in irritable states of the spinal cord and of the sympathetic, and Charcot has published some cases showing remarkable atrophy of the muscles of a joint after an injury to the articular surfaces comparatively slight and inadequate to such a result. Locomotor ataxia is usually accompanied by joint lesions. A few years ago (Ord: Belfast Address, July, 1884) it was shown that many cases of joint disease (rheumatoid arthritis, gonorrhœal rheumatism) are so associated with disturbances of the genito-urinary tract as to make it probable that there is a reflex element of causation in these disorders.

For the anatomy of special joints see the following heads: *Ankle Joint; Elbow Joint; Foot, Joints of; Hand, Joints of; Hip Joint; Knee Joint; Pelvis, Joints of; Shoulder Joint; Skull; Thorax; Wrist.*

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Frank Baker.

ARTHROPATHIES OF NEUROTIC ORIGIN.—As far back as 1831 the elder Mitchell[1] first described peculiar joint troubles that affected individuals who had suffered from cerebral disease; and in 1846 Scott Alison,[2] of London, more fully described these sequelæ, presenting several cases in which the joints of the paralyzed side only were affected. This arthritis he believed to be due to a condition of the articular surface which results from the diminished vitality of the paralyzed parts and the presence of uric acid, which under such circumstances acted as an irritative agent.

Later, Brown-Séquard[3] and Charcot[4] directed attention to the really important nature of such complications of organic paralysis, and the early researches of Alison, Durand-Fardel, Valleix, Grisolle, and others have been collected and carefully considered by them. Buzzard later investigated these *arthropathies*, especially in connection with locomotor ataxia.

It would appear that such morbid changes are usually associated with those forms of cerebral and spinal disease in which the sensory tracts are most extensively invaded, though this is by no means the invariable rule. They are common in posterior spinal sclerosis and rare in essential spinal paralysis, an affection in which disorders of sensibility are the exception. They are rare in cerebral disease without some ascending degeneration symptomatized by *pain*, and the observations of Charcot regarding the central lesion would bear this out. Arthropathies may be either cerebral or spinal, and the former are much more rare than the latter. They have been observed in connection with coarse brain disease, such as softening, with hemorrhage, tumor, or sclerosis; and are usually early symptoms of established cerebral mischief; especially is this true in the matter of hemorrhage. After a period of from fifteen days to several months after the acute central trouble we find that the joints of the paralyzed hand or foot become affected—the former more often (Charcot)—coincidently with the contractions which mark the advent of rigidity and secondary degeneration. In Alison's cases the knee and ankle were affected.

The joint disturbances begin in one of two ways: (1) Suddenly, the large joints being affected; (2) slowly, the joints of the hand and foot being the parts attacked. In the first form there develops rather suddenly, within a few weeks, a swelling which is unattended by any marked rise of temperature—at least by any such rise as we would expect to find in an acute arthritis of purely rheumatic origin. There are but little local heat and pain, but a great deal of *soreness* when the limb is moved. Jarring produces only inconsiderable suffering. I have never met with the degree of pain described by Brown-Séquard. There is more or less pain produced by pressure over the tendons, the sheaths of which seem to be involved. The joint is greatly swollen, the enlargement being made much more prominent in old cases by reason of the atrophy of muscular masses in the vicinity. There seems to be a deep involvement of the joints and of adjacent parts, and though there may be a synovitis, it is of a low grade, and, as Buzzard[5] has pointed out, there is really great tumefaction, which characterizes the familiar form of chronic synovitis, in which there are three points of swelling, viz.: above the patella, and on either side of the ligamentum patellæ.

FIG. 348.—Arthropathy of Right Knee Joint. (Buzzard.)

The appearance of the affected joint is peculiar. The swollen limb shows a duskiness and hardness in the beginning, and a cold, "white hardness" in the old cases. In some cases there is, after a few days or weeks, a subsidence of the swelling, and then certain osseous changes, to be presently described, take place.

The occurrence of *spinal arthropathy* may follow a variety of conditions. As has been pointed out by Mitchell, it may be connected with Pott's disease, with myelitis (Gull), with tumors of the gray substance of the cord (Buzzard), with posterior spinal sclerosis (Charcot), and with traumatic injury of the cord (Vignes and Joffroy).

According to Charcot the condition is often an early complication of posterior spinal sclerosis, but others think that it belongs to the late stages of the disease. It is quite true that in acute myelitis we may have a rapidly developing arthropathy, but in cases in which it is associated with a tumor of the cord or with locomotor ataxia the affection is a much more slow affair. Charcot believes that those arthropathies which affect the upper extremities in the disease under consideration are always secondary to others involving the lower extremities, and come only late in the disease as a result of extension of the morbid process. Buzzard reports a case which contradicts this, and the author has seen others.

The enlargement in the chronic variety is slow, and a point is finally reached when deep destructive processes begin, the articular surface of the bones being worn away or absorbed, so that movement of the joint on manipulation will produce a peculiar creaking or cracking sound; and when the joint has for some time been the seat of the trouble it is common for luxation to occur. The position of the extremity upon the bed is peculiar, and the patient often presents a most strange deformity. Happily the arthropathy need not always go on to this stage, and it occasionally happens that cures are made.

On the other hand, the erosion and destruction may be very rapid. Charcot says: "Even within two weeks, or sooner, the 'craquements' may be detected, which indicate a profound alteration in the articular surfaces." At the end of three months the head of the humerus, in one of his cases, was found to be almost completely destroyed.

PROGRESSIVE ARTHROPATHY.—There is a form of arthropathy of a progressive nature of which I have seen

FIG. 349.—Progressive Arthropathy Resembling Acromegaly.

but one true case, and I do not know that any other has been reported. In the patient who came under my notice, a sudden swelling of both ankles occurred, with little or no pain, and in less than one year both thumbs and ring fingers became in turn affected, and ultimately both little fingers. The metacarpal joints were the seat of a hard and quite extensive swelling, with some general œdema, more marked on the palmar surface. The patient could flex neither the thumb nor the other affected fingers, but the second and third fingers seemed to be unimpaired so far as their mobility was concerned. The ankle joints were lax and some absorption of bone had evidently taken place. There was no history of gout in this case. The patient's urine was clear and it was passed in large quantities, and I had no reason to suspect the uric acid diathesis. The affected parts had, *before* the appearance of swelling, been the seat of neuralgic pains. The right pupil was smaller than the left, and there were interesting nutritive skin changes and a peculiar slowness of gait.*

The history of arthropathies in general furnishes us with points which enable us to make a comparatively clear diagnosis. The antecedent cerebral or spinal disease is a determining factor, and the peculiar nature of the joint affection itself is conclusive. It is unnecessary to repeat here what has already been said about the possibility of confusing the condition in question with ordinary chronic synovitis. I may, however, remind the reader that the effusion is always beneath the muscles, and the skin has a polished appearance and presents no appearance suggestive of inflammation. There is often great embarrassment in flexion, though, as in Buzzard's case, extension is not interfered with, and there is no pitting at the joint. In the case alluded to, he made an application of the electrodes of an induction battery over the quadriceps muscle, just above the patella. When the swelling was very great, he obtained a powerful contraction, which proved the fact that the muscle was superficial to the fluid. The affection sometimes resembles *arthritis deformans*, but it rarely involves the hip joint. It is of sudden appearance, is often cured, the effusion is greater and the swelling more general than in the latter disease, and there are luxations as the result of erosion, which is not the case in rheumatoid arthritis.

* This case was reported in the first edition of this work, and since then it has in many ways resembled the disease which was afterward described as acromegaly.

Charcot has found in one case evidences of a true synovitis—multiplication of nuclear elements and thickening of fibrous tissue—increase in size and number of capillary vessels, and an increased amount of exudation containing leucocytes. In this case he found macroscopic lesions of the cartilages or of the ligamentous parts.

In the cases of cerebral origin a variety of interesting changes were found by Alison, but none threw much light upon the pathology of the condition, and the same thing may be said of the autopsies presented by other observers. Charcot, however, found that in locomotor ataxia there was a disappearance, upon the same side of the body, of the posterior lateral group of large cells in the anterior cornu. A case presented by Joffroy and himself was carefully studied, and it was found that the anterior gray horns were "remarkably atrophied and deformed." Fig. 350 represents a section made through the anterior horns in the cervical cord of a patient who presented an arthropathy of the shoulder joint. In a second case which was examined by these investigators, and in which the knee joint was affected, it was found that the anterior gray substance in the lumbar region had undergone a conspicuous alteration. Charcot does not believe that this degeneration is a result of functional inertia, because in his cases there was considerable freedom of movement, and the central appearances did not resemble in the least those found after amputation.

The *prognosis* of progressive arthropathy is by no means good, although it has been claimed that cures have been effected. The benefit of therapeutic measures, if to be obtained at all, must be shown at an early period, and if the morbid process has gone so far as to result in destruction of the articular surfaces, little or nothing can be gained by any treatment. It must be admitted that in spinal disease, especially when the arthropathy is associated with gastric crises and with other symptoms suggestive of advanced cord destruction, the prognosis is wellnigh hopeless.

The *treatment* of these joint affections consists in the exhibition of the iodide of potassium in very large doses —even one half, or in some cases two thirds, of an ounce daily in Vichy water—and in the free application of the

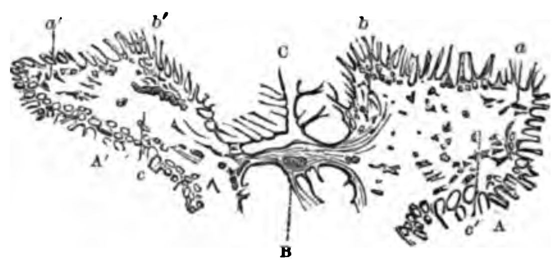

FIG. 350.—(Charcot.) A, A', Right and left anterior horns: B, posterior gray commissure and central canal: C, anterior fissure; b, b', anterior internal group of great cells: a, a', anterior external group of great cells; c', posterior external group of great cells on right side; c, locality where corresponding cells have disappeared on left side.

actual cautery to both the spine and the affected joints. Careful bandaging and the application of straps of the ammoniated-mercury plaster are of use, while perfect rest is indispensable. *Allan McLane Hamilton.*

[1] American Journal of the Medical Sciences, vol. viii., 1831, p. 55.
[2] London Lancet, 1846, vol. i., p. 277.
[3] London Lancet, July, 1861.
[4] Leçons sur les maladies du système nerveux, 1872-73, p. 100 et seq.
[5] Diseases of the Nervous System, p. 214 et seq.

ARTIFICIAL EYES.—(French, *Œil artificiel;* German, *Künstliche Auge.*)

History.—The use of an artificial eye to hide the ugliness of an empty socket or to conceal the deformity of

a shrunken and discolored eyeball dates from very early times. Historians have traced its origin to the Egyptians of the third and second century, B.C., basing their claim on the discovery of mummies and animals in whose orbital cavities artificial eyes had been placed. Artificial eyes are also mentioned in the works of Ambrose Paré (1582), and of Hieronymus Fabricius (1613). Crudely constructed of gold, silver, glass, and painted wood, the ancient eyes bore but little resemblance to the modern finished article, but were rather imitations of eyes than artificial eyes. These materials later gave way to specially prepared glass or porcelain, and toward the commencement of the eighteenth century the porcelain eyes were still further improved by an enamel, which, by reason of its durability, its resistance to the chemical action of tears, and the facility with which it received and retained colors, was generally adopted. The industry was brought to a scientific basis by Boissonneau, who introduced between 1840 and 1866 many improvements, and created practically the eye that is worn to-day.

Manufacture.—First-class artificial eyes are made in many of the large cities of Europe and America. The art consists in the preparation of the material from which the shell is made and in its shaping and coloring. The chemicals that enter into the composition of the glass are antimony, calcium, borax, uranium or manganese, oxide of tin, arsenic, and fine flint. The artist is seated before a table with a blow-pipe attached, the flame being regulated by hydraulic pressure so that it is strong and steady. To this heat the tubing, closed at one end, is subjected. As soon as it is at a white heat the maker blows the ball and shapes it, then at the proper moment he takes a stick of pigmented glass and places a drop on the summit of the ball; it is then heated again and at the same time flattened. This colored glass represents the iris. By a process of teasing the iris is made to have a blending of colors, a highly artistic process; then a darker stick of glass is fused to the centre of the iris to form the pupil; as the next step, the cornea is formed of transparent crystal. The colored tubing is now drawn out until it has the diameter of the finest silk thread, and, by using its melted tip as a brush or pencil, the delicate shadings and vein tracery are produced. After this the ball is again heated, is cut from the stem on which it was previously held, and its sharp edges are rounded off. When completed the shell has an ovoid form, concavo-convex, the surfaces being smooth and enamelled. The pupil in the artificial eye is made of the average size, or, when made to order, of the size of the patient's pupil in daylight.*

Within the past few years ophthalmic surgeons and opticians, having become dissatisfied with the results obtained by prescribing practically the same shaped eye for all orbits, have paid greater attention to the fitting of individual orbits with individual eyes, by making such alterations in their outlines and changes in their

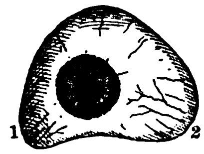

FIG. 351.

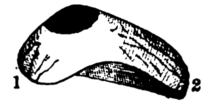

FIG. 352.

FIGS. 351 AND 352.—Fig. 351, Anterior View of Eye Adapted to Deep Upper Fornix. Fig. 352, Profile View of Same Eye: 1, Nasal extremity; 2, temporal extremity.

curvature that they may be adapted not only to normally shaped orbital beds, but to those that present cicatricial bands or other obstacles to the wearing of the average eye. Such modifications are represented in the accompanying figures.

The ingenious adaptation of the common eye of the shops, shown in Figs. 356 and 357, was suggested by Dr. J. L. Borsch, Jr., Paris, France. It may with little trouble be adapted to most orbits with entire satisfaction. In a normal socket the plate will be at right angles to the sides of the shell. The plate is fastened to the eye by means of silicate paste and the line of juncture is protected by a thin layer of wax. In order to overcome the expansion of the air contained between the plate and shell that would necessarily follow when the temperature of the eye is raised to that of the socket, the shell and plate are brought to the temperature of 100° F. or over while being cemented.

FIG. 353.—Solid Eye. One of three patterns described by Mr. Snell in *Ophthalmic Review*, and devised to avoid the suction incident to the usual concavo-convex shell.

The *object of wearing an artificial eye* is cosmetic, to conceal a glaring deformity, and therapeutic, to prevent asymmetrical growth of those bones of the face which enter into the formation of the orbit. A further object

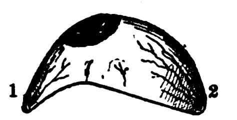

FIG. 354.—The Average Eye. 1, Nasal extremity; 2, temporal extremity.

FIG. 355.—A Complete Ball with Indentations on Superior and Inferior Sides for Lids.

is to give relief to the conjunctival irritation caused by distorted eyelids and inturned eyelashes, often the accompaniments of eyeless orbits.

The Comparative Value of Substitute Operations.—Formerly, enucleation—removal of the ball—was the only radical operation performed, but, with the object of preserving or creating a bed over which an artificial eye

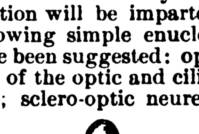

FIG. 356.

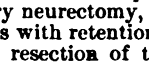

FIG. 357.

FIGS. 356 AND 357.—Fig. 356 Shows the Common Eye with a Glass Plate, which Forms the Base of the Concavity of the Eye. The plate may be cemented forward or backward, or to one or the other side, in order to tilt the cornea into any desired direction. Fig. 357, the plate.

may be worn, and by which movement and concomitant rotation will be imparted that will be superior to that following simple enucleation, various other operations have been suggested: optico-ciliary neurectomy, or division of the optic and ciliary nerves with retention of the ball; sclero-optic neurectomy, or resection of the pos-

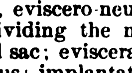

FIG. 358.

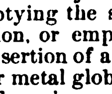

FIG. 359.

FIGS. 358 AND 359.—Fig. 358, Aluminum Button-Shaped Vitreous. Fig. 359, Aluminum Vitreous with Flat or Concave Base.

terior part of the sclera and of the adjoining optic nerve, eviscero-neurotomy, or emptying the scleral sac and dividing the nerve; evisceration, or emptying the scleral sac; evisceration with the insertion of an artificial vitreous; implantation of a glass or metal globe (such as is shown in Figs. 355 and 360) in Tenon's capsule after enucleation; abscission of the anterior third or fourth of the ball; and complete keratectomy or abscission of the cornea. But most of these operations have few advocates because of their failure to accomplish the objects

* This description is taken from the previous edition of the REFERENCE HANDBOOK. Its accuracy has been verified by the present writer during a visit to the factory of Müller Bros., Wiesbaden, Germany, in the summer of 1899.

for which they were devised or because they have been proven to be an insufficient barrier to sympathetic inflammation. The strongest rival to enucleation is the Mules' operation—evisceration with the insertion of an artificial vitreous. Operators are divided in their opinion as to the value of this procedure. It is conceded that it will give ideal cosmetic results when successful. It has, however, not been generally adopted for the following reasons: the reaction is far more severe than that after enucleation; the recovery is more prolonged—a serious obstacle to the breadwinner; the danger of sympathetic inflammation is not avoided; the artificial vitreous is subject to fracture or alteration in shape from accidents, primary success is no assurance that the vitreous substitute will be permanently retained; enucleation of the scleral sac may be demanded. The advantages claimed—viz., that the artificial eye is more movable, owing to the better stump secured, and that the operation can be safely performed in panophthalmitis—do not warrant its frequent performance or its unqualified adoption as a substitute for enucleation. If we except the isolated cases in which Mules' operation is successful, the most movable support for the prothesis is afforded when as the first step of enucleation the distal extremities of the recti muscles are united by suture to a mass that is covered by, and later becomes amalgated with, the conjunctiva.

The comparative value of enucleation, evisceration, and Mules' operation, considered only in reference to the concomitant movements of the prothesis, is well shown in the table, made from recent investigations.*

	Out.	Up.	In.	Down.	
Average rotations........	45	31	50	55	Average of Landolt's and Stevens' measurements.
Rotations after enucleation *with* suture of tendons....	19	22	20	50	Average of three cases.
Rotations after enucleation *without* suture of tendons................	15	15	12	25	Average of de Schweinitz's and True's measurements.
Evisceration..............	15	18	23	35	Average of de Schweinitz's and True's measurements.
Mules' operation...........	25	30	23	58	Average of de Schweinitz's cases.

Choice of an Artificial Eye.—In the choice of an artificial eye one must be guided by the size and shape of the socket and by the condition of the orbital contents. Only in exceptional cases is the selection from the large stock carried by opticians difficult. When irregularity of the conjunctival sac demands a specially constructed eye a leaden pattern may be moulded from which the artifical eye is fashioned. In cases of small sockets a series of leaden scales or glass shells (Fig. 360) of increasing size may be successively worn until the cul-de-sac has been sufficiently stretched. It is essential not only that the eye shall look well but that it shall be comfortably worn and not cause irritation. The points to be considered are that it shall resemble the sound eye, that it shall have both mobility and stability, and that it shall easily be adapted to the orbital contents.

Fig. 360.—Glass Shell.

The stability depends upon the accurate adjustment to the conjunctival bed behind and to the lids in front, upon the degree of curvature, and upon the length of the prothesis in relation to the length of the commissure. The size of the eye must be particularly regarded; if it is too large the lower lid is pushed in, the cul-de-sac is effaced, and the eye is spontaneously protruded; if it is too small it shifts its position independently of the movements of the other eye, and engages itself in the superior cul-de-sac, so that its lower border is protruded from the inferior cul-de-sac. A contraction of the conjunctival sac may form a bridle that will necessitate cutting a piece out of the eye or surgical intervention in the orbit for the destruction of the bridle and rehabilitation of the sac.

A defective or misfitted prothesis will cause pain throughout the entire orbit or at that portion of the conjunctiva which is wounded by the imperfection and aggravated by all movements. If the eye is too convex forward, it encroaches upon the lid at an acute angle and wounds it; if it is too flat, its posterior surface rests in contact with the cornea or with the cicatrix and produces pain. An old eye that has lost its polish gives the sensation of a foreign body in the orbit.

Fig. 361.—Lateral and Posterior View, showing expanse of sclera upward and backward for adaptation into shallow lower fornix.

To Insert an Artificial Eye.—The upper lid is elevated by traction on the skin below the orbital margin; the upper edge of the shell is introduced under the upper lid and almost in contact with it until the superior border of the cornea is hidden by the ciliary border of the lid.

The lower lid is now retracted and partly everted, sufficiently far to permit the lower edge of the eye to escape it and to pass into the lower cul-de-sac. By easy movements vertically and laterally the eye is forced into the socket, where it is held by the lids.

To Remove the Eye.—The head of a large pin or a similar instrument is inserted under the lower border of the eye, during eversion of the lower lid, and by this means the artificial eye is gently pried out so that the inferior edge may pass over the lower lid, when, by holding the head slightly forward, the eye will fall into the extended hand. After a short experience the insertion and removal of the eye are easily and safely done.

Care of the Eye.—The eye should not be worn for twenty-four consecutive hours.* At night it should be taken out and cleansed with soap and water and allowed to remain in oil until morning. Under favorable circumstances an artificial eye, when well made and fitted, will retain its polish and smoothness for about two years. In cases of much discharge of mucus and tears it corrodes in a few months, when its edges must be ground down and its surface repolished or it must be replaced by a new one.

Care of the Orbit.—How soon after operation may a glass eye be worn? The interval depends upon the reaction following operation, upon the disease of the eye that necessitated its removal, and upon the time required for perfect healing of the tissues. Writers specify the average interval after the usual operations as four weeks. We have, in a number of instances, when it was important that the patient should return to his occupation as soon as possible, inserted the eye seven days after enucleation and have had no reason to regret the action. When all signs of previous disease and of reaction from the operation have disappeared, and there has been no complaint of sympathetic trouble, the eye may be worn without fear of consequences. After enucleation for sympathetic irritation, at least two months should elapse because of the danger of exciting a pathological process that may be destructive to the opposite eye. Cases have been recorded by Lawson, Mooren, Keyser, Salomon, and Warlomont in which sympathetic ophthalmia has followed the wearing of an artificial eye over atrophied globes and after enucleation. This accident is all the more probable in the case of a stump that is ossified and painful. In threatening sympathetic disease the prothesis is badly tolerated. On the other hand, unnecessary delay enhances the difficulties of inserting and wearing an artificial eye, in consequence of shrinking of the contents of the orbit, which is prone to be rapid and progressive. For the first few days after fitting

* From a paper read by Dr. G. E. de Schweinitz before the Section on Ophthalmology, College of Physicians, Philadelphia, February, 1900.

* Dr. Chisolm has reported a case in which an artificial eye had been worn for twelve years without ever having been removed and with no bad symptoms.

an eye it should be worn only an hour or two at a time, so that the tissues may become gradually accustomed to its presence. Should inflammation of the mucous membrane arise, it is to be treated by desistance from wearing the prothesis and by applications of cauterants or astringents, such as silver nitrate, tannic acid, alum, etc.

Howard Forde Hansell.

ARTIFICIAL LIMBS. See *Limbs, Artificial.*

ARTIFICIAL RESPIRATION.—This procedure is frequently required for the purpose of sustaining a feeble and failing respiration, or to restore that function after the lungs have ceased to act. Its value as a restorative measure is undoubted, and by its use very many lives have been saved. If death in its proper sense has taken place, all efforts are fruitless, but in many instances the respirations cease, the pulse is imperceptible, and all signs indicate an absence of life, yet the heart remains in action and the blood continues to flow Clinical experience and experimental work have shown how life may be restored so long as there remains any contractile power in the cardiac muscle, and on this is based the hope of artificial respiration.

The length of time that may elapse between the cessation of breathing and its restoration is uncertain. This, however, is not of much practical importance, as in nearly all cases it is impossible to determine when the respiration ceased. In cases of drowning, smothering, poisoning, etc., there is more or less struggling and we are unable to say how much air was breathed. In the cessation of breathing during anæsthesia, and in cases of shock, the patient is under observation and the change is quite evident. In such cases assistance is at hand and efforts to restore are commenced at once. Many remarkable stories are told of long periods of suspended animation after which recovery has taken place, but all are unreliable. Three or four minutes are generally given as the limit, and it is probable that if respiration has ceased for that length of time, death has taken place. The important fact is, that a very slight interchange of air will support life, and no matter how long the respirations have apparently ceased there is the possibility of moderate breathing, and every effort should be made to resuscitate. What is of great importance is the length of time that artificial respiration should be maintained. Many cases are reported in which it was performed for ten, fifteen, and twenty minutes before breathing began, and in some cases it is stated that an hour, or even a longer time, elapsed before natural breathing was secured. It should always be continued for twenty minutes, and if there is the faintest sign of life no limit should restrict the operator. In some cases in which breathing continues, but is weak, as in opium poisoning, it may be required for hours. In the asphyxia due to gas poisoning artificial respiration may have to be kept up for days.

The apnœa, or asphyxia, which we are called upon to relieve may be produced by two distinct conditions It may arise from an absence of oxygen and the saturation of the system with carbonic acid and its products, or it may be due to a direct action on the medulla and to paralysis of respiration. In the first condition the air breathed may be impure, or charged with carbon monoxide, or there may be an obstruction to the entrance of air, as in drowning, smothering, hanging, the pressure of tumors, and in disease of the air passages. In the second condition the cause may be traced to shock, to opium, chloroform, and other poisons, and to disease of the brain.

The various methods of carrying out artificial respiration are directed to the relief of these two conditions. The alternate expansion and contraction of the lungs brings to them the pure air and carries off the impure, and, at the same time, the respiratory centre may be reflexly excited by the entrance of the pure air into the lungs, by the sudden pressure over the chest walls, and by the drawing forward of the tongue.

The preliminary treatment of the patient is of as much importance as the artificial respiration. It varies somewhat with the various causes, but it must always be carefully observed if we wish to obtain success.

In the first place, it is necessary to make a correct diagnosis. Unless the cause is known, all efforts may prove of no avail, as some important detail may be overlooked. If the air of the room is impure the patient should be removed to more favorable surroundings. If any foreign body obstructs the entrance of air it should be removed; the stenosis of the larynx should be overcome by intubation or by tracheotomy; in cases of drowning or smothering, efforts should be made to remove the fluid or foreign substance that may have entered the lungs. If poisons have been taken, the proper antidote, the stomach pump, and lavage will be required.

Whenever there are indications for employing artificial respiration the necessary steps should be taken without delay, as the first few efforts may save the patient's life. At the same time the many other means of resuscitation may be carried on by assistants. Heat to the surface of the body and the extremities is of much service; if the body heat has been lowered by exposure or by immersion in cold water this becomes a necessity. Death from drowning is much more rapid in cold than in warm water, and hope of recovery is much greater if the temperature of the body is maintained. Fortunately, heat is usually readily procured. The transfer of the patient to a warm room, the removal of his damp clothing, the application of hot blankets to the body and of hot-water bottles to the extremities, and the employment of friction over the surface of the skin, are all measures which are generally available. In some cases it may be preferable at once to immerse the body in a hot bath without waiting to remove the clothing.

Of drugs, the cardiac and respiratory stimulants, such as strychnine, digitalin, ammonia, ether, and brandy, may be administered hypodermically; also hot stimulating rectal enemata may be used. Oxygen may be added to the air inhaled, particularly in the asphyxia of noxious and poisonous gases.

Blood-letting has been recommended. In all cases in which the system has been deprived of oxygen, the lungs are congested and the right cavities of the heart are distended. Under such conditions the abstraction of venous blood will lessen the engorgement and allow the heart to regain its contractile power.

So far as the question of position is concerned, it is generally recommended that the patient's body be inclined slightly upward and a pad of clothing be placed under the back to raise the chest, as this allows of the greatest degree of expansion. Under ordinary conditions this advice should be followed, but in the failure of respiration during anæsthesia it is desirable at once to lower the head and shoulders, as this position favors the flow of blood to the cerebral centres and will of itself revive many patients. In cases of drowning the patient should first be placed with the face downward and the head lower than the body, the tongue being drawn forward. This allows any water that may be present to escape, and the emptying of the lungs may be further assisted by pressure on the chest walls. The position of the head is a matter of the utmost importance, as upon it, in a great measure, depends the freedom of the air passages. In asphyxiated patients the relaxed tissues allow the epiglottis to close the larynx and the tongue to fall back against the posterior pharyngeal wall. It was generally taught that traction on the tongue would overcome both these obstructions, but it is now well known that drawing the tongue forward exerts little or no influence on the epiglottis unless the base is grasped and very forcibly raised. The epiglottis, however, is very readily raised and the air passages kept free by maintaining the head in a proper position; but much confusion has arisen from the many positions that have been advocated. Sylvester, in describing his method of artificial respiration, directed the head to be held "in a line with the trunk." The committee of the Royal Medico-Chirurgical Society, in their report on artificial respiration, states that "when the head of the subject was allowed to hang back over

the edge of the table, air seemed to pass into the chest more readily than when the back of the head rested on the table." A few years later, Dr. Howard in his investigations arrived at the same conclusion, and in his directions he recommends that "a roll of clothing be placed under the back just below the shoulder blades, the head hanging back as low as possible." In a later paper (*Lancet*, May 22, 1880), in discussing the proper position of the head to keep the epiglottis raised, he states: "Having, by bringing the patient to the edge of the table or bed, or by elevation of the chest, provided that the head may swing quite free, with one hand under the chin and the other on the vertex, steadily but firmly carry the head backward and downward; the neck will share the motion, which must be continued till the utmost possible extension of both head and neck is obtained." These diverse views caused some confusion in regard to the proper position in which to place the head, but neither one supplanted the other. The influence of Dr. Howard's work, however, was widely felt, and many cuts representing Dr. Sylvester's method of resuscitation represent the patient with shoulders raised and head hanging low.

Professor Hare, in a paper (*Johns Hopkins Hospital Bulletin*, January, 1895) in which he described some experiments made upon this subject by himself and Dr. Edward Martin, has advanced a step further and advocated an entirely different position of the head. While agreeing as to the effect of the Howard position on the epiglottis, he shows that it at the same time causes the soft palate to apply itself against the dorsum of the tongue and thus cut off the entrance of air through the mouth. The importance of this is apparent when we consider how large is the number of persons in whom the nasal passages are more or less obstructed. He states: "If the head is extended and simultaneously projected forward, both the tongue and epiglottis are raised, and the soft palate is so drawn as to permit of free breathing through the mouth as well as the nose."

Of the many methods of performing artificial respiration, that introduced by Dr. Henry R. Sylvester (*Rankin's Abstract*, 1858, ii.) is almost universally adopted. Modifications suggested by others may be combined with it, but in nearly all cases the principles of this method are followed to a greater or less extent. The object is to imitate the action of the respiratory muscles, by alternately raising and lowering the arms. The patient is placed upon his back, and the movements are made slowly and deliberately about fifteen times in the minute. The directions are as follows: "Standing at the patient's head, grasp the arms just above the elbows, and draw the arms steadily and gently upward above the head and keep them stretched upward for two seconds. Then

FIG. 362.—Sylvester's Method (First Position). Patient's arms extended to allow the entrance of air into the chest.

turn down the patient's arms and press them gently and firmly for two seconds against the sides of the chest."

In 1856, two years previous to Dr. Sylvester, Dr. Marshall Hall had introduced his "ready method." In this the patient is placed on his face and pressure made upon the back to expel the air in the lungs. He is then turned on the side, in which position the lungs can more easily expand. The directions are: "Place the patient with the face downward and one of the arms under the forehead, in which position the tongue will fall forward leaving the entrance into the windpipe free. Turn the body very gently on the side and a little beyond, and then briskly on the face again. Repeat the movement about fifteen times per minute, occasionally varying the side. On each occasion that the body is placed on the face,

FIG. 363.—Sylvester's Method (Second Position). Patient's arms pressed against the sides of the chest to expel the air.

make uniform and efficient pressure on the back and sides, removing the pressure immediately before turning the body to the side."

These rival methods produced a great deal of controversy. Each one had its followers who praised their method and decried the other. The subject attracted so much attention that the Royal Medical and Surgical Society appointed a committee to inquire into the relative merits of the two methods. The work of this committee was very thoroughly done and their report was a valuable contribution to the subject of artificial respiration (Trans. Royal Med. Chir. Soc., vol. liii., 1862). In regard to the two modes, the evidence was very decidedly in favor of that advocated by Dr. Sylvester. They found that by his method the amount of air drawn into the lungs averaged about thirty cubic inches, while in Marshall Hall's method not more than fifteen cubic inches could be obtained. Quite recently, in 1895, Hare, in his experiments, which were carried out with much more exactness, obtained the same preponderating evidence in favor of the Sylvester method. He found that the amount of air expelled from the lungs, when the latter method was employed, was sixty-two cubic inches, while in Hall's it amounted to only twenty-two cubic inches.

In addition to the advantage just mentioned, there are others which Sylvester's method possesses. It may be easily and perfectly carried on by one person, while the other method requires the presence of an assistant to support the head in a proper position. In the former the two sides of the chest are being acted upon, while in Hall's method only one side is undergoing expansion.

Another method, ascribed both to Professor Pacini and to Dr. Bain ("Holmes' System of Surgery," v., 906), requires that traction be made directly upon the shoulders. According to Prof. Pacini, the operator, standing at the patient's head, should place a thumb upon the head of each humerus and his fingers in each axilla, and should then draw the patient upward by the shoulders until he occupies a sitting posture. According to Dr. Bain's method the operator's hands are to be placed in such a manner that the thumbs shall rest upon the patient's clavicles while his fingers press against the sides of the chest in the axillæ. The next step is to lift the patient's shoulders upward.

In the older methods of resuscitating the apparently drowned the effort was made to expel the air from the lungs by simply compressing the chest walls; it being assumed that the natural elasticity of the ribs would suffice for effecting a re-expansion of the lungs. Another factor upon which some dependence was placed was the reflex contraction which takes place in the diaphragm when pressure is exerted upon it. Among these methods special mention should be made of that of Dr. Benjamin Howard (*Lancet*, August 11, 1877). It is thus described by its author: "Turn the patient face upward, the roll of clothing put under his back just below the shoulder blades, the head hanging back as low as possible. Place the patient's hands together above his head. Kneel with

the patient's hips between your knees. Fix your elbows against your hips. Now, grasping the lower part of the patient's chest, squeeze the two sides together, pressing gradually forward with all your weight for about three seconds, until your mouth is nearly over the mouth of the patient; then, with a push, suddenly jerk yourself back. Rest about three seconds, then begin again. Repeat these movements about eight or ten times a minute."

In what is known as the Michigan method, the patient is placed with the face downward. The operator stands astride the body and seizing the shoulders raises them as high as he can without permitting the head to leave the floor, and then returns them to their original position; he next places his hands on the lower ribs and presses downward and inward with gradually increasing force; he then suddenly lets go to begin again with the first motion.

Another way that is frequently recommended is to apply pressure to the soft abdominal walls, directing it upward against the diaphragm. In this way a large amount of air is expelled; but the objections are, that considerable force is required and that there is danger of injuring neighboring organs.

Dr. Howard Kelly (*Johns Hopkins Bulletin*, January, 1895) describes a method which he has adopted and which should prove of service when the respirations cease during an abdominal section, as it prevents the escape of the abdominal contents during the manipulations. It also places the patient in the most favorable position under such circumstances, the value of the lowered head being well recognized. He thus describes it: "An assistant steps upon the table and takes one of the patient's knees under each arm, and thus raises the body from the table until it rests upon the shoulders. The anæsthetizer in the mean while has brought the head to the edge of the table, where it hangs extended and slightly inclined forward. The patient's clothing is pulled down under her armpits, completely baring the abdomen and chest. The operator, standing at the head, institutes respiratory movements as follows: inspiration, by placing the open hands on each side of the chest, posteriorly, over the lower ribs, and drawing the chest wall forward and outward, holding it thus for about two seconds; expiration, reversing the movement by replacing the hands on the front of the chest over the lower ribs, and pushing backward and inward, at the same time compressing the chest."

A very valuable addition to our many methods of resuscitation is that of Professor Labord, presented to the Paris Academy of Medicine, in 1892, and the subject of numerous papers in the *Tribune Médicale* during the following year. The object of this method is to induce reflex action on the part of the diaphragm and lungs by traction on the tongue. He traces the impulse through the glosso-pharyngeal and lingual nerves to the respiratory centre, and thence to the phrenic and other respiratory nerves. The mode of applying this method is extremely simple. After the ordinary preliminary measures have been carried out the tongue is held deeply and drawn forcibly forward, about fifteen times to the minute. The claims of Professor Labord are, that it not only is a good means of resuscitation, but the best, and in his reports of successful cases there are many in which other methods had been adopted without success. Very many others have also reported favorable results. Two points are to be carefully observed, viz., to grasp the tongue deeply so that the whole organ is acted on and not the tip only, and to draw the tongue sharply and relax it suddenly and completely. As in all methods it must be conducted patiently for some time. During its performance other methods of exciting the reflex action may be attempted. The finger of the other hand may be placed in the pharynx, the mucous surfaces of the nose and fauces may be tickled, or ammonia and other volatile substances may be used. Labord's method is particularly valuable in resuscitating newly born infants. In them the lungs have not acted, and some excitation is required to awaken the respiratory centre. Sylvester's and similar measures are not of much service in such cases, as the respiratory muscles are not properly developed, nor can the compression of the chest walls avail, as the lungs have not yet been inflated.

In infants dependence must be placed on reflex excitation and insufflation. For the former we have Labord's rhythmic traction of the tongue, slapping the surface of the body, etc., while at the same time an attempt may be made to compress the chest walls and to carry out Sylvester's movements. To inflate the lungs, the most ready method is to breathe directly into the mouth of the child eighteen or twenty times a minute. To insure a proper passage of the air, the larynx is to be pressed upward and back, to close the œsophagus, the tongue is to be drawn forward, and the nasal cavities are to be closed. Expiration is aided by pressing upon the chest walls. Catheters or rubber tubes may be introduced into the larynx, and various bellows and pumps have been devised for forcing air into the lungs, but the objections to them are, the valuable time lost if they are not at hand and the difficulty in placing them in proper position for use.

Faradization has been proposed as a means of contracting the diaphragm, and has been employed as an adjunct to other efforts to inflate the lungs. It is not of much value alone, but should always be utilized when at hand. One electrode is to be pressed over the right phrenic nerve, just outside the carotid artery, while the other is to be placed over the lower ribs. The left side is avoided in order not to interfere with the heart's action. The current should be applied regularly during the elevation of the arms, and cut off as soon as the arms begin to descend. The abdominal electrode should not be placed too low for fear of contracting the abdominal muscles instead of the diaphragm.

In all attempts at artificial respiration it is quite evident that one method must not be followed to the exclusion of all others. Fortunately, no one of them precludes the employment of another, but rather there is every reason to expect a greater benefit from their combined use. If a sufficient number of assistants are available, Sylvester's, Labord's compression of the chest walls, and electricity may be conducted at the same time. The only precaution required is, that they should be carefully and regularly conducted, and that the various efforts to promote inspiration and expiration should coincide.

Beaumont Small.

ARUMBARO SPRINGS.—Municipality of Morelia, State of Michoacan, Mexico. These springs are thermal. According to an examination by Dr. Zuñiga the water presents the following characteristics: "Perfectly transparent, yellow in color, unctuous to the touch, of a saline taste and alkaline reaction." A qualitative examination showed the following chemical ingredients: carbonates of calcium, magnesium, potassium, sodium and iron, sulphuric, sulphurous, and phosphoric acids, chlorine and organic matters. Total solids per United States gallon, approximately 118 grains. The soda salt appears to be the preponderating constituent. The water discharges sulphureted hydrogen in abundance, giving to it its peculiar odor. It is used for bathing, although no buildings have so far been erected. The baths appear to be beneficial in cases of eczema, herpetic eruptions, rheumatism, and diabetes.

N. J. Ponce de León.

ASAFŒTIDA.—"A gum resin collected from *Ferula fœtida* (Bunge) Regel (fam. *Umbelliferæ*)" (U. S. P.). To this definition the British Pharmacopœia adds "and probably other species."

Over the desert steppes of Western Asia grow in great numbers a variety of gigantic perennial species of *Umbelliferæ*, which perpetuate themselves during the long dry seasons by very large fleshy roots, protected against decay and foraging animals by antiseptic and obnoxious resins and volatile oils. So abundant are these plants that immediately after the occurrence of the first rains,

it is their germinating leaves which, according to the traveller Aitchison, chiefly impart the tinge of green to the landscape. Later, these huge leaves interlace so thickly as to become obstructive to travel, and huge flower stalks shoot up to the height of many feet. These, like their branches, terminate in great umbels of small greenish or yellowish-white flowers. Among these plants are numerous species of the genus *Ferula* L., several of which have been supposed to yield the substance under consideration. It is fairly well established that this is collected from the species named above, as well as from *F. asafœtida* L., assuming these to be distinct. It is probable also that it is collected from *F. narthex* Boiss., and perhaps also from *F. alliacea* Boiss. and *F. persica* Willd. The young leaves and shoots of these plants are used as pot herbs in their native home.

The history of asafœtida in Europe before the twelfth century is not clear, although it has been held to have been an article of commerce from near the beginning of the Christian era; but, from the twelfth century down, there is no doubt of its presence in European drug lists. On the other hand, of its use in Asia there is evidence in Arabian and Sanscrit writings of great antiquity.

The principal supply of this drug is collected in Afghanistan, and exported to India (Bombay), whence it comes to Europe or America. It is usually packed in large cases, but sometimes in bags or "mats."

Our knowledge of the collection of asafœtida rests principally upon the evidence of two travellers, who had the fortune to see it at an interval of nearly two hundred years from each other. The first of these was the celebrated Kaempfer, who observed it in the Persian province of Laristan. His description has been repeatedly quoted, and is, in the main, as follows: "About the middle of April, when the leaves have done growing, the fields are visited by the peasants, who dig away the ground around the older roots, tear off the leaves from the crown, and then carefully cover it up with earth and leaves, to protect it from the rays of the sun. After leaving the plants in this way for several weeks, they again uncover them, remove a portion of the top and cover them again, being careful that nothing touches the newly cut surface. In one or two days more the exuded juice is scraped off with a knife, a fresh surface is made by cutting off a thin slice, and the covering is repeated. This is continued until the root is exhausted, the product growing better as the season advances. The soft juice is mixed with earth to give it body."

The other authority is Staff Surgeon Bellew, who saw asafœtida collected during a visit to Afghanistan in 1857. The process was something like that observed by Kaempfer, but it was done at a season when the young leaves were sprouting, and instead of cutting off the top of the root they cut or gashed it in several places; the digging away of the earth and the covering of the roots to keep off the heat of the sun were the same in both cases. Mr. Bellew states that the juice is mixed with gypsum or flour, although some very fine juice, obtained from the bud, is usually sold pure. This latter, like the fine juice of Kaempfer's later cuttings, probably never reaches the European markets.

Good asafœtida, when the cases are first opened, is a moderately soft, yellowish-gray, rather tenacious mass, of a not very homogeneous texture; sometimes lighter, whitish or yellowish tears are common in the mass; oftener coarse impurities are the cause of its unevenness. Upon exposure, this light-colored asafœtida turns first pink, or reddish plum or violet pink, and then gradually becomes brown. Its odor is characteristic; strongly alliaceous, penetrating, and persistent. It is exhaled, like that of onions, in the breath of persons taking it. Taste bitter and acrid, nauseous. When in lumps, even if long kept, asafœtida is usually not quite brittle, but if finely broken and dried it can be ground to powder, in the cold.

The quality is considered fine according to the abundance of clear, whitish tears which it contains, and the absence of impurities and insoluble residue. Occasionally specimens are met with, consisting wholly of tears, but these are rare. The United States Pharmacopœia requires that it should dissolve at least to the extent of sixty per cent. in alcohol.

In spite of this requirement, such asafœtida cannot now be found in our markets. Very much of it will yield little more than twenty per cent., and importations yielding as low as twelve per cent. have not been unknown of late. This state of the asafœtida trade has been regarded as in the nature of a scandal in the United States Custom Department. Many authorities suggest lowering the standard to accommodate the adulteration, but it would appear a better policy to apply drastic methods of exclusion, which would doubtless cure the evil radically, even though slowly. When it is considered that the chief cost of the article is the result of its long transportation, much of it over very expensive stages, it will be recognized as exceedingly wasteful to import from eighty to ninety per cent. of sand and crushed stone. Polisek, in 1897, determined the composition of an almost pure sample of asafœtida to be as follows: "Ether-soluble resin (ferulic acid ester of asaresinol tannol, $C_{24}H_{33}O_4OH$), 61.4; ether-insoluble resin (free asaresinol tannol), 0.60; gum, 25.1; volatile oil, 6.7; vanillin, 0.06; free ferulic acid, 1.28; moisture, 2.86; foreign matter, 2.5." This composition is by no means constant, as the relative proportions of resin and gum, and to a less extent of the oil, are quite variable. The impurities and ash should not exceed ten or fifteen per cent. The gum is mostly insoluble in water. The resin yields resorcin when fused with potassa, and umbelliferon and oils when subjected to destructive distillation. The oil is light yellow and possesses very strongly the odor of the drug. It is related to the volatile oil of mustard, but is not, like it, a strong local irritant. It is of a very complex composition, which has not yet been perfectly worked out. It contains about twenty-five per cent. of sulphur.

Asafœtida is a typical antispasmodic, as well as one of our best carminatives. It stimulates the appetite and the gastric secretions and movements, as well as the internal functions. As an antispasmodic it is particularly useful in hysteria, and is sometimes useful in spasmodic affections of the respiratory organs, as pertussis and asthma. It frequently permits sleep by allaying excitement, and especially by removing intestinal irritation. It is very largely used in veterinary practice. The dose is 0.3 to 1.5 gm. (gr. v. to xx.). Four preparations are official: The Pilulæ Asafœtidæ contain each 0.2 gm. (gr. iij.) asafœtida and three times as much soap; the Pilulæ Aloes et Asafœtidæ contain 0.09 gm. (gr. 1½) each of aloes, asafœtida, and soap; the Emulsum Asafœtidæ (formerly "Mistura") has a strength of 4 per cent. and the dose is 15 to 30 c.c. (fl. ℥ ss. to i.). This preparation is remarkably effective when used as an enema, in which case the dose may be doubled. The tincture has a strength of 20 per cent. and the dose is 2 to 4 c.c. (fl. ʒ ss. to i.). Asafœtida is frequently used externally in plasters, being a mild rubefacient.

It may be added that asafœtida renders bait attractive to certain fishes, notably bullheads. *H. H. Rusby.*

ASAPROL.—Abrastol-beta-naphthol-alpha-mono-sulphonate of calcium—$C_{10}H_6.OH(SO_3)_2Ca+3H_2O$. An aqueous solution of beta-naphthol-alpha-mono-sulphonic acid is saturated with calcium carbonate, and the salt crystallized out. It is a white or pale reddish crystalline powder without odor and soluble in one part and a half of water and three parts of alcohol. It is of neutral reaction, is not changed by heat, and is incompatible with the sulphates, and with quinine and antipyrine. It is antiseptic, antineuralgic, and antirheumatic, and is eliminated by the kidneys in the form of a naphthol sulphuric ether. It may be detected in the urine by the formation of a blue ring on the addition of ferric chloride.

Internally it may be employed as an antiseptic in intestinal indigestion, enteritis, and typhoid fever. As an antirheumatic it is claimed by Dujardin-Beaumetz,

Buck, Stackler, and others that asaprol is equal in value to the salicylates, and at the same time does not cause headache, buzzing in the ears, and depression of the heart. It has been tried with moderate effect in influenza, malaria, and chorea, and with relief of the pain in neuralgia. Locally, as antiseptic, astringent, and styptic it may be applied in one to four per-cent. solution or ointment, and in whooping-cough a one-per-cent. solution may be sprayed into the throat.

The dose internally is gr. xv. to lx., or more, three times a day, given in gaultheria water or elixir of orange, or in capsules. For typhoid fever gr. iij. to v. should be given every two hours. *W. A. Bastedo.*

ASARABACCA. See *Snakeroot, Canada.*

ASBOLINE.—A product of the destructive distillation of pine roots, prepared by Braconnot. It is a yellowish or brownish oily-looking liquid consisting mainly of pyrocatechin, homopyrocatechin, and allied substances. It is used in medicine against the tubercle bacillus.
W. A. Bastedo.

ASCARIS LUMBRICOIDES. See *Nematoda.*

ASCITES.—(Synonyms. Hydrops Ascites, Hydroperitoneum, Dropsy of the Peritoneum.)

DEFINITION.—Ascites is an accumulation of free fluid in the peritoneal cavity.

It is either (1) a part of a general dropsy involving pleuræ, pericardium, and the subcutaneous tissues of the body, or (2) a strictly localized dropsy caused by disease in the peritoneal cavity. Class (2), if of long standing, may secondarily cause œdema of the legs, as a result of the anæmia which usually develops, or as a result of pressure upon the iliac veins. Class (1) includes diseases of the heart, kidneys, lungs, and blood. Class (2) includes atrophic and hypertrophic cirrhosis of the liver, cancer and syphilis of the liver, amyloid liver, atrophy of the liver due to external pressure or growth, abscess or echinococcus of the liver causing pressure upon the portal vein. Tumors of the stomach and pancreas, peritoneal adhesions and enlarged lymphatic glands may cause ascites by pressing upon the portal vein. Thrombosis of the portal vein or of the inferior vena cava likewise may cause ascites. Chronic peritonitis, either simple, tuberculous, or cancerous, and perihepatitis chronica (*Zuckerguss-leber*) are causes of ascites. Leukæmia and splenic anæmia are occasionally associated with this condition; and so also are intrathoracic growths and mediastino-pericarditis. A small ascites may occur in apoplexy; it has also been noted in intestinal obstruction. Occasionally on the post-mortem table there have been found, in the different cavities of the body, collections of fluid which had not been demonstrated by physical signs during life. Immediately preceding death there is an intense congestion of the viscera which frequently results in an outpour of serum. This condition, when involving the peritoneal cavity, is termed preagonal ascites.

PATHOLOGY.—From an etiological standpoint all varieties of ascites (chylous ascites is discussed under the corresponding heading in Vol. II.) may be classed under three heads:

1. Ascites due to stagnation of blood in blood-vessels.
2. Ascites due to interference with the escape of lymph.
3. Ascites due to disturbance of capillary secretion, *i.e.*, alteration in the walls of capillaries.

In certain diseases we have combinations of the above causes: for example, a chronic heart disease with incompensation may secondarily produce changes in the capillary walls, as a result of lack of nourishment resulting from the imperfect renewal of blood.

The third class is distinctly a conception of modern pathologists and will require more detailed discussion. The former belief that the process which resulted in dropsy was merely a filtration of fluid through an animal membrane has been discarded. It is now held that the capillary walls are to be regarded as living organs with a capacity for secretion. The prompt passage of the crystalloids from the blood and the lymph is accomplished with the aid of a force inherent in the capillary walls. The fact that the proportion of salts or of sugar in the lymph is often greater than that in the blood suggests a capillary secretion. The fact that the proportion of albumin in pure transudates in different parts of the body varies considerably, points to a differing constitution of the vessel wall in these several regions. According to Reuss' table, transudates in different parts of the body give the following percentages of albumin:

Pleura	22.5 pro mille.
Pericardium	18.3 "
Peritoneum	11.1 "
Subcutaneous cellular tissue	5.8 "
Cerebral and spinal fluid	1.4 "

Heidenhain believes that the specific function of the capillary walls plays a controlling part in the formation of lymph. Whenever the removal of lymph fails to keep pace with its formation, dropsy results. This investigator has demonstrated that the formation of this material can be influenced by various substances present in the blood. Subcutaneous injections of an infusion of crabs or leeches so increased the transudation of water from the blood-vessels into the lymph that the quantity of lymph flowing from the ductus thoracicus was increased even to fifteenfold. This exciting substance must stimulate the specific functions of those capillary cells in the capillary walls which secrete the lymph. Class 3 includes the varieties of ascites usually termed inflammatory and cachectic. In the majority of cases, the changes in the vessel walls are the result of protracted ischæmia, of imperfect oxygenation, or of chemical changes in the blood, or are due to the effect of high or low temperature or to active traumatism. It is also probable that either irritation or paralysis of the vasomotor nerves may lead to an increased vascular secretion. The exact changes in the vessel walls are not known, but there are probably alterations of the endothelial cells and of the cementing substance between them. It is quite possible that Class 3 may include Class 1 and that our so-called pure transudates of obstructed circulation are capillary secretions rather than filtrations, the capillary cells being stimulated to secretion by irritating substances circulating in the blood.

In cases of hydræmia with œdema, Ziegler looks upon the increase in the amount of water in the blood as only one factor which is favorable to the occurrence of œdema. In cachectic and nephritic subjects œdema occurs often when no hydræmic plethora is present, and conversely œdema may be absent when hydræmic plethora is present. So it is held that the œdema of cachectics and nephritics is due to alteration in the vessel walls caused either by the hydrated condition of the blood or by a poison circulating in the blood.

Two factors are present as causes of ascites in inflammatory changes in the peritoneum, viz.: alterations in the walls of the blood-vessels, and the destruction of a large number of lymphatic vessels through which the fluid, secreted in excessive amount, should be carried. The ascites almost invariably associated with perihepatitis chronica is to be explained by the coexistence of a chronic peritonitis. In a few cases of perihepatitis in which there was no ascites, general peritonitis was absent. *Ascitic fluid* is either a transudate or an exudate. Transudates are found in non-inflammatory conditions and are usually light yellow in color, while exudates are found in inflammatory conditions and are darker in color. There are essential differences in their composition, a fact which may be of aid in diagnosis. Peritoneal transudates have a specific gravity varying between 1.005 and 1.015, while that of exudates frequently reaches 1.030. The difference in the specific gravity is due to the difference in the amount of albumin; exudates contain from four to six per cent., while transudates con-

tain from one to two and a half per cent. Transudates do not coagulate spontaneously; in exudates a coagulum is frequently observed after standing for twenty-four hours.

Microscopically the transudate shows only a few isolated leucocytes and endothelial cells derived from serous surfaces and undergoing fatty degeneration. Exudates contain many more formed elements and may be serous, sero-fibrinous, sero-purulent, purulent, putrid, hemorrhagic, chylous, or chyloid.

Following the administration of potassium iodide it is possible to obtain the iodine reaction in ascitic fluids.

ETIOLOGY.—Atrophic cirrhosis of the liver is the most common cause of ascites. It is less commonly found in the hypertrophic form. The frequency of ascites in diseases of the heart and kidneys is illustrated by the statistics of 300 cases of general dropsy, as revealed after death, taken consecutively from the post-mortem books of St. George's Hospital, London, from 1888 to 1897. One hundred and sixty-three of these were due to affections of the heart or aorta. As regards ascites, 1 in 2.5 of the cardiac cases and 1 in 2.2 of the renal (not lardaceous) cases presented this condition. Any of the organic heart lesions when incompensated may be followed by ascites. It is most frequently associated with mitral stenosis. The pleuræ and peritoneum are especially liable to dropsical invasion with the large white kidney of nephritis and the advanced granular kidney in which secondary cardiac changes have been added to the renal. Diseases of the lungs, such as emphysema and fibroid changes, may cause ascites by obliterating pulmonary vessels. This results in an increase of pressure in the right heart, and secondarily in the veins and capillaries, with transudation.

DIAGNOSIS.—*Inspection.*—In ascites of moderate degree with the patient lying down, the abdomen is full at the sides and flat on top; in the upright position it projects below the navel. If the ascites is enormous there is a uniform distention and no change of shape with change of position. The superficial abdominal veins become enlarged in cases of long standing. In cirrhosis of the liver the veins surrounding the umbilicus may become very prominent and form the caput medusæ. When the amount of fluid is excessive there is a marked hernial protrusion of the navel.

Palpation.—Fluctuation is obtained by placing one hand flat upon one side of the abdomen, and tapping gently on the opposite side with the other, as in direct percussion. A similar sensation may be felt, however, if the abdomen be very fat or tympanitic. In order to exclude this pseudo-fluctuation, an assistant presses the edge of his hand along the linea alba; this manœuvre does not interfere with the transmission of the wave in ascites, but effectually interrupts it in the other conditions mentioned.

Percussion.—In the horizontal position there is dulness at the sides, and tympany over the upper and middle portions of the abdomen. The fluid seeks the dependent parts and the intestines float to the top so far as the mesentery will permit. The area of dulness changes with the position of the patient. On assuming the side position, dulness is obtained over the lower side and tympany over the upper. If the ascites is enormous, the intestines and stomach do not reach the surface, consequently there is dulness over the entire abdomen. The amount of fluid necessary for demonstration varies with the size and sex of the patient.

Toma's sign has been employed to distinguish between an exudate and a transudate, or inflammatory and non-inflammatory conditions. In inflammatory conditions of the peritoneum the mesentery contracts, drawing the intestines over to the right side. As a result, the patient assuming a horizontal position, tympany is elicited over the right side and dulness over the left.

Exploratory puncture is the crucial test, and should always be employed before operation.

DIFFERENTIAL DIAGNOSIS.—The ascites of heart disease is associated with a dusky skin, while that of Bright's disease is associated with a pale skin. Diseases of the heart, lungs, kidneys, and blood should be excluded by careful examination. A satisfactory examination of the abdomen by palpation can be made only after the withdrawal of the fluid. Palpation is then very easy on account of the relaxed abdominal muscles. An enlarged liver or spleen, growths on the liver or in the neighborhood of the portal vein can then be easily felt. At times the nodules of tuberculous or carcinomatous peritonitis can be made out. If primary cancer or tuberculosis is found in other parts, the problem is simplified. The great value of microscopical examination of the fluid, as a material aid in differential diagnosis, should be strongly emphasized. The fluid should be centrifugated, the sediment spread on cover slips, dried in the air, fixed in absolute alcohol and ether, then stained with hæmatoxylin. Quincke, Rieder, Dock, and Warthin have found in exudates cells which seem peculiar to cancer and sarcoma of serous membranes. Rieder found cells undergoing division, their nuclei presenting numerous karyokinetic figures, especially asymmetrical division forms, which are found to a slight degree or not at all in endothelial cells. Dock found in cancerous effusions more cells showing mitoses than in simple or tuberculous inflammations. Warthin concludes from his investigations that the presence of numerous cell-division forms in the cells of the sediment of serous exudates may be taken as strong, perhaps conclusive, evidence that the effusion is due to the presence of a new growth, inasmuch as mitoses are but rarely found in cells of purely inflammatory exudates. Quincke claims that carcinoma probably exists if a marked glycogen reaction can be obtained in the endothelial cells. Endothelial cells are sometimes mistaken for the so-called cancer cells. Quincke states that the diagnosis should be made only when large epithelial cells of variable form, measuring at times 120 μ in diameter, are found in large numbers, especially when arranged in groups, unless indeed cancerous nodules presenting the characteristic alveolar structure are found. Hemorrhagic exudates are as a rule tuberculous or cancerous. The fluid should be centrifugated, spreads made and stained for tubercle bacilli; though these are rarely found even in undoubted cases of tuberculosis of the peritoneum. A guinea-pig should be inoculated with the sediment, since even when the bacilli are not found the pig often develops tuberculosis. The diazo reaction is occasionally present in the urine of tuberculous and cancerous peritonitis, but does not help in differentiating one from the other, as it has been found in both.

The quantity of fluid varies greatly with the disease, but is usually largest in atrophic cirrhosis of the liver and in perihepatitis chronica. W. Hale White reports the case of a patient with perihepatitis who was tapped thirty-five times; the total amount of fluid withdrawn was seven hundred and ninety pints; the largest quantity taken out at one time was thirty-one and a half pints. Pütz's case of atrophic cirrhosis of the liver was tapped forty-seven times, with the removal of twelve hundred litres of fluid, during a sickness of four years' duration.

PROGNOSIS.—The majority of the patients die within two years. Some cases associated with incompensated heart lesions recover under cardiac treatment and live for many years. Occasionally a case of cirrhosis of the liver recovers, if a sufficient collateral circulation is established. Numerous recoveries have been reported in cases of tuberculous peritonitis with ascites, treated by laparotomy. Many theories have been advanced to explain the cause of recovery in these cases. There are tuberculous diseases of the peritoneum which heal spontaneously. Hildebrandt believes that laparotomy only increases the natural healing factors. This author believes that the venous hyperæmia which ensues is the important factor in the healing of tuberculous peritonitis. Following operation he has observed an involution of the tuberculous process, and in isolated cases a complete healing with disappearance of the tubercles which he

had seen in the first laparotomy (*Münchener med. Wochenschrift*, 1898, Nos. 51 and 52).

TREATMENT.—The ascites, if troublesome, should be relieved immediately, and treatment directed to the causative disease instituted if advisable. The first is most successfully accomplished by the simple surgical procedure of tapping. This operation is strikingly free from the danger of infecting the peritoneum. Flint refers to a patient who frequently tapped himself with a jack-knife and used a clay pipe stem for a cannula.

Aspiration, or the introduction of Southey's tubes, may be resorted to.

If the diagnosis of tuberculous peritonitis seems probable, then laparotomy should be performed. The fluid may collect so rapidly that it is necessary to tap every fortnight or oftener, but frequent tappings do no harm. In ascites due to heart disease and anæmia, treatment appropriate to these diseases should be given. The use of diuretics and hydragogue cathartics is usually unsatisfactory. The value of the dehydrating effect of dry diet should be emphasized. Care should be taken in selecting appropriate cases, since it is well borne in cardiac dropsy and poorly borne in renal dropsy.

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ASCLEPIADACEÆ.—(*Milkweed Family.*) This immense family, of more than two hundred genera and fifteen hundred species, is an exceedingly difficult one for botanists. There is probably no other family the relations of whose members are so poorly known, so that any present system of classification must be regarded as very arbitrary. Nevertheless, the composition and properties of its members are singularly uniform. Its plants, with few exceptions, abound in a milky juice which possesses acrid, narcotic, and nauseating properties, so that a great many of them have been used as nauseating expectorants, alteratives, and mild counterirritants. The glucoside *asclepiadin* occurs frequently in this juice, as do many other glucosides. The only plants which have been much used in professional medicine are several species of *Asclepias* (see *Pleurisy Root*) and *Condurango*. Many are, however, used in native and domestic practice. In India especially, a large number of species have been used, the principal of which are described by Dymock and Hooper in the "Pharmacographia Indica" as follows: *Cryptostegia grandiflora* Br., which is poisonous and yields a rubber. *Calotropis gigantea* R. Br. and *C. procera* R. Br., which are irritant purgatives; *Tylophora asthmatica* W., and A. which is a nauseating expectorant; *Dæmia extensa* Br.; *Dregea volubilis* Benth.; *Hemidesmus Indicus* Br., the root of which is a much-used and powerful diuretic; *Cosmostigma racemosum* Wight.; *Gymnema sylvestre* Br. and many others less well known.

H. H. Rusby.

ASEPSIS, SURGICAL.—That wound infection and suppuration are the result of the presence of vegetable micro-organisms is no longer a theory but a fact proven by experimental research and clinical experience. While no one will deny that wounds may, under certain conditions, heal kindly without the use of any precautions to prevent the entrance of minute living organisms, such result obtains with great rarity, and not in consequence of a lack of these precautions but despite such negligence. The almost complete disappearance of hospital gangrene, the greatly diminished frequency of other forms of wound infection, the very low mortality rate, the safety with which the abdominal and cranial cavities are invaded at the present time, render unassailable evidence of the value of surgical asepsis. The term asepsis now indicates an absence of germs in a wound. Unfortunately, we are as yet unable to obtain a condition of absolute asepsis. There is perhaps in every wound some form of organism present, but by proper application of the means now at hand, aided by the resistance in the tissues, we are enabled, in a large percentage of wounds, to obtain healing without inflammation or suppuration. In the development of our present methods of asepsis, Lister stands out as the pioneer, and although his idea that air infection was very dangerous has been proven fallacious and the spray has fallen into disuse, the present technique is the direct outcome of his teaching. Other investigators have added to our knowledge during the time that has elapsed since his writings, and the present technique is the result. The object in wound treatment is to prevent anything coming into contact with the wound surface which can convey infection, and to limit the number and the virulence of bacteria whose entrance cannot be prevented. To accomplish this end requires unremitting care and attention to detail as well as a thorough appreciation of the dangers resulting from the slightest oversight. The more cleanly a surgeon is in his daily life, the more easily can he form habits of surgical cleanliness. Many surgeons obtain poor results because of an imperfect technique and fail to perceive such imperfection. Only by a careful investigation of poor results can the evil be remedied. The young surgeon educated to-day under the influence of the present teaching more readily learns and practises aseptic surgery than one who was taught and practised under the old régime. The infectious agents are bacteria of different forms which exist in the air, the soil, and the clothing, upon the skin and mucous membranes of the healthy body, in the beard and hair, and especially under the nails. The number of bacteria in the air is inconsiderable compared to the number found in the other places mentioned. The infection occurs as a rule by contact with a broken surface. If the chances of contact infection are excluded, air infection becomes of little moment. This can be almost entirely eliminated by care to prevent dust being raised in a room. No sweeping, brushing, taking down of curtains, opening windows or doors on opposite sides of a room should be allowed just before an operation. A moist cloth can remove dust and dirt with the least possible disturbance. Bacteria can scarcely leave a moist surface and pass into the air.

There is some tendency at the present time again to attribute greater importance to air infection, as certain investigators have obtained virulent cultures of the pyogenic bacteria from the air of hospitals. The methods of handling dressings and wound discharges will determine, to a large extent, the number of bacteria which reach the air. It is important, therefore, to destroy all wound dressings and not allow them to lie about in a dry condition. That flies and other insects can be the medium of transportation is well established, and while perhaps not a frequent means of infection yet it is well to exclude them from hospitals, for this reason as well as for the comfort of the patients, by the use of screens. The most frequent source of wound infection is the hands of the surgeon and his assistants. This can be readily appreciated when we consider the great fre-

quency with which the surgeons and their helpers are called upon to handle cases in which bacteria are present in countless numbers, all possessing some degree of virulence. In the language of Keith, "It is the willing and tender though unclean hand" which conveys the infection. Therefore the fewer and better trained the assistants, the better the results obtained. If the chain of careful technique is broken by any of these, the result will be infection with its consequent inflammation, suppuration, and sepsis.

The very greatest care cannot prevent the occurrence of an occasional contamination of the wound surface. But in direct proportion to the care exercised will the danger of infection be lessened. Every surgeon should assume the right to inspect the hands and nails of his assistants and accept or reject them, for he alone is responsible for the outcome of the case. No mere washing for one minute in this and for one minute in the other solution will render the hands sterile. Rubber gloves or finger cots sterilized for each case will prove very useful in handling septic cases with the least chance for contamination. Those working in the deadhouse or in putrefying materials should not perform or assist at surgical operations.

All who handle wounds should keep the idea of asepsis always before them and should carefully avoid needless contamination of their hands. In dressing wounds which are suppurating or are infected contact should be avoided as much as possible. From fifteen to thirty minutes' careful scrubbing with soap, water, and freshly sterilized brush are necessary for the mechanical cleansing of the hands. The water either should be running or should be changed frequently during this process. The soap should be carefully selected and germ free. Ordinary green soap is very frequently used for this purpose. A cheap brush of vegetable fibre can be obtained which has the advantage of not being injured by boiling. Each person engaged in the operation should have an individual brush for his final scrubbing. The nails should be kept short and all visible dirt should be removed by a sterilized scraper after a primary washing and before the final scrubbing which should extend above the elbows. Such mechanical cleansing is the first step in all plans of sterilization of the hands. In hospitals the final cleansing of the hands is preceded by a complete change of the clothing, the operator and assistants removing the outer clothing and donning a white sterilized suit and cap. Some operators go so far as to change the shoes as well. In private practice such a change is not often possible, therefore the coat, vest, collar, and tie are removed and a large sterilized apron is used to cover the clothing to within a few inches of the feet. In such way the object desired can be accomplished. If the apron and clothing beneath become saturated with water, care must be used to prevent such spot coming into contact with the wound, hands of surgeon, or anything which will touch the wound.

A number of investigators have made bacteriological tests of the efficiency of different methods for the preparations of the hands. In 1885 Kümmel made a number of experiments to determine the value of different antiseptic solutions, such as boric acid, thymol, carbolic acid, and corrosive sublimate. After rinsing the hands in soap and water, and immersing in one of the above solutions, he drew his finger tips over the surface of a sterile nutrient gelatin. He found the colonies least abundant when five per cent. carbolic or 1 to 1,000 bichloride of mercury was used. He concluded that primary importance should be attached to the mechanical cleansing, while chemical agents were of secondary importance. Förster about the same time obtained the same results. Fürbringer in 1888 showed that a sterile culture resulting after such a test by no means indicated that the fingers were sterile, for scrapings from beneath the nails of such fingers would, when thrown on gelatin, produce an excessive growth of bacteria. This result was obtained even after the utmost care in cleansing and scraping this part prior to the disinfection. He was led to believe that the grease adherent to the skin protected the germs from the action of the chemicals. Acting on this idea he used a strong solution of alkali, which proving inadequate he abandoned for ether. This was not satisfactory owing to its rapid evaporation. Alcohol was found to have the solvent property of ether without the rapid evaporation. His method was as follows:

1. Thorough cleansing of subungual space.
2. Scrubbing the hands for one minute with water and soap.
3. Scrubbing hands with sterile brush in eighty or ninety-five per cent. alcohol for one minute.
4. Rinsing in three per cent. carbolic or three-tenths of one per cent. of bichloride solution.

He did not claim germicidal action for the alcohol. The more recent investigations show that the tests with alcohol give as good results without the fourth step as when the germicides are used. The great objection to bichloride of mercury is the cracking of the hands which follows its use. Some operators, notably Kelly and others, use the solution of potassium permanganate and oxalic acid (Schatz' method) in addition to the mechanical cleansing mentioned before; others use turpentine, and still others use sterilized ground mustard in their technique. Less depends upon plans used than upon the thoroughness with which the preparation is accomplished. The method most in vogue is some modification of Fürbringer's with the use of a longer time for the preparation than his instructions would indicate. First scrub the hands and arms to elbows with soap and water, after cleansing nails thoroughly until no dirt is visible. Then scrub thoroughly the hands, arms, and crevices about the nails in a basin of alcohol for at least five minutes. This, with or without the use of bichloride of mercury, will give the best results and has the advantage of being very simple and easy of application. After this preparation has been completed, the greatest care should be exercised to keep from touching anything which is not sterile. That almost irresistible desire to scratch the nose or to adjust spectacles must be controlled.

Mikulicz advised the use of sterile cotton gloves to protect against infection from the hands. As might be expected, this was not successful owing to the facility with which fluids passed to and from the hands carrying microbes through the gloves. More recently thin rubber gloves and fingers cots have been introduced to provide a sterile finger and hand. These are not injured by boiling or by steam, therefore can be made perfectly sterile, and will undoubtedly have a large field of usefulness. The chief objection that can be offered to rubber gloves is that they interfere to a greater or less extent with the manipulations. Some surgeons, however, become quite expert in their use and claim that the tactile sense is not perceptibly lessened. The finger cots allow greater freedom to the hands but do not cover them sufficiently and if not snug may be left in the wound. This might prove troublesome in operations in the abdomen and other cavities. Sterile glycerin or sterile talc will aid in putting the gloves on the hand. The cleansing process must be just as thorough as when operating without the gloves. Dr. A. C. Wiener, of Chicago, has suggested the use of celluloid dissolved in acetone as a substitute for collodion. Enough celluloid is dissolved in the proper amount of acetone to produce a thin syrupy liquid. For holding small dressings in place, sealing wounds and abrasions of the hands before operation, and like purposes, it appears to be superior to collodion, as it adheres much more tenaciously.

Dr. James B. Bullitt, of Louisville, Ky, has proposed the possibility of eliminating the finger nail and crevice as a factor in wound infection by sealing up the nails by means of this preparation. He has found that if a thin solution be first applied to the nail and the contiguous skin and then, after this has dried, in a few minutes a further coat, or coats, of a thicker solution of the consist-

ence of cream be applied, that the nails can be completely sealed. If a half-hour's time be then given for drying and hardening it will be found that the hands can be thoroughly washed, scrubbed with a brush, and subjected to all of the usual preparations for a surgical operation without the celluloid loosening its hold. In using this material for such purpose, it is recommended that the hands and nails be thoroughly washed and prepared just as is usual for operation, and that the celluloid be then applied, after which it is desirable to permit a half-hour to elapse before the hands are again placed in water. Sealing the nails in this way leaves the tactile sense of the fingers unimpaired, an objection offered by many operators to the use of gloves, whether of rubber or of cotton fabric. Bacteriological investigation upon this point will be of interest, and if the method achieves the object desired it will prove quite an adjuvant to our present technique.

The Patient.—It is undoubtedly a fact that the condition of the patient is often responsible for a wound infection. It has been proven that bacteria can and do exist in the blood of apparently healthy individuals, only becoming localized after a trauma, and in other cases the resistance of the tissues is below par; therefore, when time is allowed, the patient should be placed on tonics and nutritious food. The kidneys, skin, and intestines should be rendered active. In this way the bacteria present are eliminated and the resistance of the tissues to infections is increased. A number of warm or Turkish baths should, whenever practicable, be given prior to operation. One warm bath should be insisted upon in all cases in which it does not endanger the patient. A bichloride of mercury bath will render the bacteria on the surface less active, but is irritating to sensitive skins. On the afternoon before an operation is to be performed the field should be shaved and thoroughly cleansed with soap, water, and brush. This should extend some distance away from the point of incision. The scrubbing should be done gently when over a suppurating lesion in the abdomen, to prevent rupture. After rinsing with plain sterilized water a bichloride scrubbing should be added, then the part should be covered with a thin layer of green soap, and over this a thick fold of gauze, or in lieu of this a gauze compress saturated with bichloride of mercury solution, 1 to 2,000, should be laid.

Sensitive skins are sometimes blistered if either of these applications is left on too long. Especial attention must be given to the axilla, the umbilicus, the pubes, and also the scalp. The preparation of mucous surfaces will of necessity be more or less imperfect. The object is to promote the highest degree of asepsis possible with the least injury to the mucous membrane, for the intact membrane will resist infections much better than one which has been damaged. The eye cannot be scrubbed and cannot stand any strong germicides to promote asepsis. Moreover, the normal secretions in this part seem to have some antiseptic action. The integumentary surfaces of the lids and brows should receive a thorough scrubbing with soap and water. The conjunctival sac should be irrigated thoroughly with a saturated solution of boric acid or Thiersch's solution. If the conjunctiva or the tear sac is infected, no operations upon the eye should be undertaken except those of emergency. The results will certainly justify waiting until the process subsides under proper treatment. The nose can be cleansed only by the use of the spray or douche and some of the simpler antiseptic solutions, of which an ordinary saline is one of the best. Dobell's solution is also very popular. Prior to operations about the mouth it is advisable to have a dentist care for the teeth in order that the chance of infection will be diminished. Before an operation the teeth should be thoroughly scrubbed with brush and tooth wash or powder. The mouth should then be washed out with tincture of myrrh, peroxide of hydrogen, or bichloride of mercury solution, and subsequently rinsed with plain sterilized water. The anus and rectum can be cleansed by means of two or more scrubbings of external parts followed by plain enemata prior to the operation. And when the patient is anæsthetized, the bowel can be thoroughly scrubbed with soap and water and flushed with a weak solution of corrosive sublimate followed by one of plain boiled water. The same plan can be followed with the vagina, using a small nail brush, a jeweller's brush (Gerster), or a small piece of gauze on forceps to reach the upper part. About five days prior to a trachelorrhaphy, after cleansing the vagina, the cavity of the uterus should be curetted and cleansed by flushing with carbolic or bichloride solution and plain water. Many operators advise the same step before a hysterectomy, but it is not generally considered necessary. The *room* should be light and well ventilated, devoid of curtains or superfluous furniture. The temperature should be about 75° F. It should be so arranged that cleaning can be easily accomplished by means of a mop and wet cloths without impregnating the air with dust. When operating in private houses the furniture, carpets, and curtains must not be disturbed at the time of the operation. The utensils should be glass, porcelain-lined, or granite ware which can readily be rendered clean and sterile by hot water. Hard rubber makes the best portable trays, owing to its light weight. The tables and other furniture for the operating room should be of the simplest kind, and those made of iron and enamelled, with or without glass tops, are the best. Where these cannot be obtained a plain table made of hard wood will answer every purpose. They must be kept scrupulously clean. All basins, pitchers, etc., which will be used should be well scoured and boiled or scalded just prior to use. Sheets and blankets should be sterilized and the patient should be well covered except at the site of operation. The towels must be sterilized and kept tightly wrapped until ready for use. These materials may be sterilized in the same way that gauze and dressings are prepared.

Sponges.—The best silk sponges are expensive so that resterilization would be necessary, and this is more or less unreliable. Boiling unfortunately hardens the sponges and destroys their usefulness. This has rendered their thorough sterilization somewhat difficult. Very good sponges can be obtained for about two dollars and a half per pound, and these can be thrown away after an operation. Many methods of preparing sea sponges have been proposed. The following (Schimmelbusch) is useful and very simple: The sponges are beaten, washed, and kneaded repeatedly in cold and warm water until the dirt, shells, and other foreign matter are entirely removed. They are then pressed together, surrounded by gauze, and put into a one-per-cent. solution of soda, just removed, while boiling, from the fire. They are kept in this solution for half an hour. The soda is then washed away with boiled water and the sponges are stored in a tight jar and covered with a solution of bichloride of mercury (1 to 2,000).

Still another method of sterilizing sea sponges is the following: After the usual beating and rinsing to free from dirt and lime, they should be immersed in a solution of muriatic acid, ℥ij. to O i, for twenty-four hours. They should next be soaked in a saturated solution of permanganate of potassium, and then decolorized in a hot saturated solution of oxalic acid. The latter is removed by passing the sponges through lime water. When washed in plain sterilized water they are placed in a solution of bichloride of mercury (1 to 1,000) for twenty-four hours and are kept in three-per-cent. solution of carbolic acid until needed. In the latter steps of preparation the sponges should be handled by means of sterilized rubber gloves and sterile forceps. The difficulty of sterilization and the cost are objections to sea sponges, and while the advantages of a good sponge are apparent, its place is being largely taken by pads of absorbent gauze and mops or wipers made of cotton covered by gauze (Tupfers). These can easily be made by squares of gauze with diagonal corners tied together and enclosing a small pledget of cotton. When desired they can be made of very small size for use in cavities. They are easily sterilized by steam and are very convenient

and inexpensive. As far as possible the edges should be turned in to prevent ravellings being left in the wound. These mops and pads should be wrapped in gauze, one dozen in a package, and so sterilized. In this way they can readily be counted so that none shall remain in the wound. Large flat gauze pads with a string attached are now often used in abdominal work in place of the large flat sponges formerly so much in vogue.

The *instruments* should be made entirely of metal, of very simple design and easily cleansed. They should be kept perfectly clean by thorough scrubbing with brush, soap, and water before and after each operation. This should have the most careful attention lest shreds of tissue and clots of blood remain. Proper cleansing having been obtained, the instruments may be rendered sterile by boiling in one-per-cent. solution of carbonate of sodium for five minutes. The sodium salt seems to aid in the destruction of micro-organisms which may be present (Schimmelbusch). It also prevents rusting of the instruments which occurs in plain water. The ordinary fish kettle is very useful for boiling instruments, as the tray can be lifted and the instruments transferred to another tray or towel without being handled. Wiping them and placing in a towel exposes them to a chance of contamination and is not as a rule advisable. Cutting instruments unfortunately lose their edge when boiled, hence other means are necessary to render them germ free. Immersion for a short time in alcohol, then in pure carbolic acid for five or ten minutes, again in alcohol which dissolves the carbolic acid, and finally in freshly boiled water will be the best plan for sterilization. Germicidal drugs other than carbolic acid are seldom used for the preparation of instruments. Bichloride of mercury acts destructively upon metal. After sterilization the instruments should be kept in basins and covered with hot water or towels and should not be handled again before the operation. One assistant should have entire charge of the instruments, or, perhaps better, the table containing them is so placed that the operator can get them himself. If an instrument falls upon the floor, is handled by septic hands, or is soiled by infectious material during an operation, it should be discarded or resterilized. When not in use instruments should be kept in a clean, dust-proof case.

The Dressings.—Butter or cheese cloth is almost universally used at the present for a wound dressing and is known to the profession as gauze. Surgeons' absorbent cotton is also very largely used as a wound dressing. Other materials, such as oakum, jute, etc., are used less frequently. The materials most suitable for bandages are butter cloth, unbleached cotton, flannel, and crinoline. The dressing, gauze, cotton, and bandages, also aprons, towels, gauze sponges, blankets, and sheets, can all be rendered aseptic by exposure to steam in a sterilizing apparatus for one hour on three successive days. The sterilizer of Arnold, E. Boeckman, or a similar one may be used for this purpose. The chief object is to obtain a moving or live steam with sufficient pressure to be forced into all parts of the material undergoing sterilization. Heat applied before closing the sterilizer will tend to prevent condensation of the steam and saturation of the dressings. The same end can be reached by allowing the steam to pass through the materials after opening the sterilizer. When taken from the sterilizer they should be dry and subsequently handled as little as possible and with the greatest precaution to prevent contamination. If folded in gauze before sterilization they should be opened only when ready for use and in the mean while confined in closed retainers.

Sutures and Ligatures.—The suture and ligature materials now in use are catgut, silk, silkworm gut, kangaroo tendon, silver wire, and horsehair, each having its peculiar indications for use. Of these, catgut and kangaroo tendon are sterilized with most difficulty. The other materials are less readily affected by heat and are therefore the more easily rendered sterile. The former have, however, the advantage of being readily absorbed, and will be on this account less likely to act as a foreign body and prove subsequently a source of irritation. Silkworm gut is not absorbent, has no tendency to become softened by wound secretions, and is therefore not so likely to carry infection into the wound as catgut or silk. It is very useful when a firm, strong, and nonabsorbable material is indicated. Silk sutures and ligatures should be rolled on glass spools and sterilized with the dressings by steam or by boiling in plain water just before use, or the method in use at the Johns Hopkins Hospital (Halsted) can be adopted. The silk is cut in lengths of from nine to twelve inches, and ten of these strands are wound on a glass reel. Several of these reels of desired sizes of silk are placed in a glass tube, which is loosely plugged with cotton. The tube is then placed in a steam sterilizer for an hour on the first day and on the two following days for half an hour each time. When removed from the sterilizer the cotton is pushed tightly into the tubes, and they are kept in aseptic glass jars until wanted. Frequent boiling of silk appears to lessen its strength to some extent. Boiling silk or silkworm gut in soda solution will soften it and cause deterioration. The sterilization of catgut is a more difficult task, and most methods have been far from satisfactory. The prepared gut offered for sale is as a rule most unsatisfactory; this is especially true of that kept in oil. The latter is, however, rarely sold at the present time. Catgut kept in alcohol in a sealed glass tube can be sterilized by boiling for two hours. Kelly for some years used catgut that had been soaked in ether and then boiled in absolute alcohol under pressure, but he abandoned the method after several cases of infection, which were thought to be due to imperfect sterilization of the gut, had occurred. He has recently used Kronig's cumol method modified by Clark and Miller. This he describes as follows: 1. Cut the catgut into desired lengths and wind twelve strands into a figure-of-eight form so that it may be slipped into a large test tube. 2. Bring the catgut gradually up to a temperature of 80° C. and hold it at this point one hour. 3. Place the catgut in cumol, which must not be above a temperature of 100° C.; raise it to 165° C. and hold it at this point for one hour. 4. Pour off the cumol and either allow the heat of the sand bath to dry the catgut or transfer it to a hot-air oven at a temperature of 100° C. for two hours. 5. Transfer the rings with sterile forceps to test tubes, previously sterilized as in the laboratory. Cumol is not explosive but very inflammable; care must therefore be used to keep it from the flame. Kangaroo tendon is not generally used, but is useful when early absorption is not desired. It can be prepared in a manner similar to that employed for the sterilization of catgut. The irregularity of the tendon makes it somewhat difficult to handle. Silkworm gut can be readily sterilized by steam or by boiling and can then be kept immersed in alcohol. It can, however, be boiled with the instruments at the time of operation and thus rendered perfectly sterile. By cutting off the two irregular ends of the required number of strands and making the first turn of a reef knot, they can easily be handled and one strand removed at a time by holding at the knot and pulling it from the convexity of the loop. Another good plan is to place the strands in test tubes in which they can be sterilized and kept aseptic until ready for use. Silver wire is easily sterilized by boiling with the instruments. It is a favorite suture with many operators, especially when a considerable thickness of tissue is to be approximated. Some abdominal operators use it in suturing the abdominal wall in tiers. It is, however, not so frequently used as some of the other materials and often causes irritation when embedded in the tissues. Horsehair makes a very valuable material for suturing the skin where tension will be slight. Black hairs are best as they are larger and stronger. The hairs are readily prepared as follows: Take a small bunch of hair from the horse's tail and brush it in a direction opposite to its growth to remove the short hairs. Then wash it thoroughly, first in soap and water to remove grit and dirt, and then in ether to remove fats. Finally, boil and

keep in alcohol until needed for use. Or the small bundles can be put into a test tube and sterilized by steam as is done in the case of silkworm gut. The hair suture is best inserted as a buttonhole suture or as the chain stitch of Billroth. In order to do this, tie the first stitch as in simple continuous sutures, then pass the needle through both lips of the wound and hook the emerging end of the suture under the other to lock the stitch.

Fluid for Irrigation.—Water as generally seen is not germ free. The best and simplest method to render it sterile is by boiling with or without previous filtration. The latter is to be preferred, because there will be less sediment and the vessels will the more readily be kept clean. These vessels should be provided with covers which are put in place after the sterilization. It is well to supplement the cover by a few folds of sterile gauze or a towel. Some of the water should be sterilized long enough before the operation to allow time for cooling. The dipper for conveying the water from one vessel to another can be sterilized with the water. In fresh and clean wounds germicidal solutions are to be used only in preparing the field and the hands prior to operation, and only plain sterile water or a normal salt solution, 6 to 1,000, used during the operation. In accidental wounds and septic conditions an effort is to be made to destroy the organisms by the use of chemicals such as 1 to 1,000 bichloride of mercury solution, or from one to five per-cent. solution of carbolic acid, or one-per-cent. solution of acetate of aluminum. In fresh aseptic wounds many surgeons use the dry method of operating and obtain excellent results. No fluids of any kind come into contact with the wound, and dry gauze sponges remove the blood. In this way one of the things necessary for bacterial growth, moisture, is markedly lessened.

The Drainage.—Material for drainage is used to remove from wound spaces the serum which would form a pabulum for bacterial growth, and in accidental or infected wounds to remove pus and incidental colonies of bacteria, but in many cases some additional drainage material is necessary. This object may be accomplished by a simple counter opening at a dependent part. Strands of sterilized silk, horsehair, catgut, and silk-worm gut are frequently used for this purpose. The other materials which are employed for drainage are gauze and tubes made of decalcified bone (Neuber), of glass, or of pure rubber, fenestrated as desired. The latter is one of the best and most universally used. Glass tubes are used almost exclusively in abdominal and pelvic work, and are less useful in other parts of the body. Tubes of glass and rubber can be made perfectly sterile by boiling, and they produce as little irritation as any of the other forms of drain. Owing to the tendency the tissues have to become adherent to the meshes of the gauze, it has been proposed to surround the gauze drain by gutta-percha tissue. This tissue cannot be boiled as it is destroyed by heat, and dependence must be placed on alcohol, bichloride of mercury, or other chemical disinfectant which is washed away before the drain is inserted.

Drainage should be employed only when there is a distinct reason for so doing, as where there is excessive wound secretion, where contamination of the wound has occurred, where dead spaces are unavoidable, and where the wound is connected with mucous surfaces. The danger of contamination of the wound through drainage must not be overlooked. When the object for which the drain has been inserted has been accomplished, or when its presence produces irritation, its use should be discontinued. The size of the drain must be suited to the amount of fluid to be removed. If rubber tubing is used, it should just emerge from the skin to prevent flexion and obstruction, which may occur if it projects too far out, and it must not be choked by the pressure of the nearest suture. A sterilized safety pin passed through the margin will prevent the tube slipping into the depths of the wound.

The Wound.—In making a wound the surgeon should endeavor to injure the tissues as little as possible, using sharp knives and making a clean-cut incision. The tissues should be torn asunder as little as possible so that the amount of dead tissue will be small, thus lessening the favorable soil for bacterial growth. For the same reason rough sponging and injurious chemicals are to be avoided. Hæmostasis must be complete, and suitable drainage arrangements should be made for the removal of the wound secretions in the larger wounds and in those in which infection is likely to take place. The dead spaces must be as nearly as possible effaced by position, suturing, and bandaging; in fact, everything should be excluded from the wound which will lessen the vitality of the part or form a nidus for the growth of bacteria. It is a well-known fact that too much tension upon a suture will favor the formation of a stitch abscess; therefore the stitches are to be drawn only tight enough to approximate the edges without tension. When the suturing is complete, the wound and adjoining field should be freed from blood by a piece of moist gauze and dried thoroughly. The dressing is then to be applied, the character of which will depend largely upon the situation and size of the wound. The small and superficial wounds can be sealed by the use of collodion or celluloid, and if a drain is needed its point of emergence can be left open. In the latter case it is wise to apply a sufficient quantity of gauze over the wound to take up the secretion, and then to cover this with cotton and a bandage. In the larger wounds plain sterilized gauze in voluminous folds should, after being shaken up, be applied and covered with cotton and a bandage. The part is then to be placed at rest, and if an extremity, in an elevated position. The application of chemical dusting powders to the wound will depend largely upon the experience of the operator. The substances most used for this purpose are iodoform and boric acid, neither of which is germicidal or sterile as usually seen. Iodoform can be made sterile by placing it in a gauze bag and immersing in a strong solution of mercuric chloride.

For some years the writer has adopted the practice of dressing aseptic wounds without any dusting powder, and has found that they remain dry and heal as kindly as with the use of such substances. When an inspection of the wound is demanded there is no crust covering the wound to prevent the discovery of a small focus of suppuration, and there is no obstruction to the free removal of wound products by the dressing. When it is found necessary to use adhesive plaster for coaptation or to prevent separation of wound surfaces, several folds of sterilized gauze should be placed between the wound and the adhesive, for this material cannot be rendered sterile.

Subsequent Dressings.—The same degree of care in the preparation of the hands should be observed for the dressing of wounds as at the time of the operation. Rubber gloves and finger cots will find a very useful field where many wounds are to be dressed in succession. If drainage has been used, the wound should be dressed at the end of twenty-four or forty-eight hours, and the gauze or tube removed. After this time there should be some distinct indication for such interference before the wound is again disturbed. Repair will not be hastened by needless inspection. Fever, pain, odor, and saturation of dressings will indicate the necessity for an examination. The sutures should be removed when they have fulfilled the indication of their insertion or when they are producing irritation and thus are failing in this purpose.

Accidental Wounds.—A large percentage of such wounds are infected before they reach the surgeon and therefore require especial efforts at sterilization. The wound and surrounding skin must be thoroughly cleansed with soap and water, and washed with an antiseptic solution, either of corrosive sublimate (1 to 2,000) or of carbolic acid (1 to 100). The solution is removed by flushing with sterile water. Complete approximation is not often advisable and drainage is the rule rather than the exception. A dusting powder, of which iodoform is the best, may then be applied, and over this the same dressing as in an aseptic wound. Van Arsdale has recommended the use of a five-per-cent. solution of balsam of Peru in castor oil as a wound dressing. This can be sterilized by heat and will

be found useful especially in accidental and suppurating wounds. It prevents the dressings from adhering to the wound and permits of their easy and almost painless removal. The appearance of infection in a wound demands the establishment of free drainage and the use of antiseptic irrigation. The application of a hot, moist antiseptic dressing will often prove beneficial.

Asepsis of Special Operations.—In abdominal operations, in which contamination of the cavity by pus, fæces, bile, or urine may be feared, it is essential that the general peritoneum be protected by the interposition of gauze pads or sponges to take up such material. These sponges or pads are removed after the field has been cleansed and the danger of further contamination is passed. Following this, the general cavity is to be flushed thoroughly and a complete toilet made. Similar steps are necessary in opening a cerebral abscess which is likely to be followed by a general inflammation of the meninges. Some minor surgical procedures demand aseptic precautions, such as aspiration and injection of cavities, saline infusion—hypodermic injections—and the use of catheters and sounds for urethra, bladder, and ureters. Aspirators and syringes should be so constructed as to be easily sterilized. A hypodermic syringe is now on the market which is made entirely of metal and can be boiled. Overlach's syringe with rubber piston, glass barrel, and metal mountings can also be sterilized by boiling. The needles should be boiled in soda solution before they are used. The fluid to be injected into the tissues should be boiled, unless it is itself germicidal. Fountain syringes made of rubber or glass can be boiled and are frequently used for making saline injections into the blood and tissues. They must be freshly sterilized before they are used. It is essential that the skin should also be sterilized in such procedures. It is claimed by Cazeneuve and others that the urine from healthy kidneys in a healthy bladder is always sterile. Decomposition of the urine and inflammation of the bladder occur only as the result of the presence of micro-organisms, which as a rule enter from without. The entrance of septic germs does not always produce an inflammation of the bladder, as they are rapidly expelled with the urine. Any obstruction to outflow will favor their retention and growth, and the development of inflammation in the ureters and kidneys as well. Every effort must be made, therefore, to prevent infection of this tract. Catheters are made of soft rubber, metal, silk, or linen sealed by gum. The metal and soft rubber are best. They should be sterilized by boiling for five minutes, and then anointed with sterilized glycerin or oil before they are introduced. Sounds and other instruments should be treated in the same way. If such procedure would injure the instrument, dependence must be placed on a strong carbolic solution. Brisk friction for one minute with a wet towel followed by similar treatment with a dry cloth will make the solid instruments sterile (Schimmelbusch). A virulent urethritis contraindicates catherization, and before any instrument is passed, the urethra should be cleansed by the evacuation of the urine or by flushing the canal with water or normal salt solution. Constant watchfulness in all surgical procedures, both large and small, is absolutely essential for the prevention of septic contamination. This watchfulness can be cultivated to a very high degree so that it becomes more or less a matter of habit. When this occurs, however, there enters the danger of carelessness. Therefore it is well to remember that our technique is always open to improvement and that the danger lies in indifference and a lack of care.

J. Garland Sherrill.

ASEPTOL is the trade name of a solution of sozolic acid, of the strength of thirty-three per cent. Sozolic acid, $C_6H_4(HSO_3)OH$, is formed when carbolic acid is dissolved in concentrated sulphuric acid, in chemically equivalent parts. It is a syrupy, reddish-brown fluid, miscible in all proportions in water, alcohol, and glycerin. It is less poisonous than carbolic acid and has a more agreeable odor. Specific gravity; 1.168. It possesses antiseptic properties and is used externally for the same purpose as carbolic acid. It is devoid of caustic properties, is less irritating, and is not so powerful an antiseptic, being estimated to possess about one-third its germicidal power. A solution of ten per cent. may be generally employed as an antiseptic wash. In diphtheria it is recommended as a local application. It may be given internally, but the official salt, sulphocarbolate of sodium, is to be preferred.

Beaumont Small.

ASH BARK.—The bark of various species of *Fraxinus* L. (fam. *Oleaceæ*). The commonly used species are the *F. excelsior* L. of Europe and the *F. Americana* L., or White Ash, of America, the inner root bark of which has been employed. The fluorescent glucoside *fraxin*, very common in the genus, seems to be less important therapeutically than the volatile oil and amaroid, which are present with a considerable amount of resin. Its composition would indicate its utility as a stimulant to nutrition. Its empirical use in the treatment of dysmenorrhœa and metritis is, however, not explained. The dose is 1 to 4 gm. (gr. xv. to lx.), and it is advised to be given in the form of a wine.

H. H. Rusby.

ASH, PRICKLY.—XANTHOXYLUM. "The bark of *Xanthoxylum Americanum* Miller and of *Xanthoxylum Clava-Herculis* L. (fam. *Rutaceæ*)" (U. S. P.). Prickly ash derives its name from its armature of thorn-like prickles and its superficial resemblance, when in flower, to the true ash (*Fraxinus*), to which it is not related. The genus *Xanthoxylum* L., as recognized by Bentham and Hooker, contains nearly one hundred species, distributed widely in both temperate and tropical regions of both hemispheres. In most of these regions, one or more species are used as ours is, and many of them are employed also in fish poisoning. Of the two species named above, the former is the northern, the latter the Southern prickly ash. The latter is regarded by Dr. Engler as representing a distinct genus, *Fagara* L., and is called by him *F. Caroliniana* (Lam.) Engler. This view is apparently correct.

The fruits of both the northern and southern species have composition and properties generally similar to those of the bark, and are used similarly, but in rather smaller doses. The Cuban species, to which the name *X. Clava-Herculis* L. has also been applied, is a distinct species (*X. Caribæum* Lam.). Northern prickly ash is a large shrub, rarely attaining to the dimensions of a very small tree. Its spines are not borne upon corky protuberances. Southern prickly ash becomes a small tree, and its spines, at least upon the older portions, are elevated upon large conical corky excrescences. The bark of the former is in small quills or pieces of them, very thin (rarely exceeding one twentieth of an inch in thickness), brown or purple with light gray patches, very rarely entirely gray, and usually with minute black spots resembling fly specks. Its inner surface is smooth and whitish, becoming yellow, and with a greenish tinge. It has a sharp, brittle fracture, exhibiting an outer green and an inner yellowish-white layer. The southern bark is even thinner in quills of the same size, though the older pieces become twice as thick, and it is more uniformly gray. The spine characters assist in the differentiation. Both barks have a very bitter and pungent, afterward acrid taste.

Composition.—As to their general nature the constituents agree in the two barks, though the compounds are different. There are two resins, one very acrid. The oil is also very acrid. The bitter taste is due to a distinct substance, *xanthoxylin*. A small amount of tannin is also present.

Properties.—The action of prickly ash is that of an aromatic bitter, but it has other characteristic properties. Its locally stimulating powers are very marked. Externally it is an active counterirritant and relieves neuralgia and rheumatism. It excites profuse secretion in the mouth and stomach, and apparently in the intestine.

It stimulates the heart quite strongly, apparently reflexly. It promotes excretion as well as secretion and is an excellent diaphoretic, diuretic, and expectorant. This eliminative power makes it of service in the treatment of rheumatic and syphilitic conditions. It was one of the most extensively used of aboriginal drugs, and has always been a favorite in domestic practice, and it is unfortunate that it has been displaced professionally by less worthy articles. The official preparation is the fluid extract, the dose of which is 1. to 4.0 c.c. (fl ʒ ½ to 1). The root of *X. Senegaleuse* DC. is similarly used under the name of *artar root*. It contains the alkaloid *artarine*.

H. H. Rusby.

ASHEVILLE, N. C.—Asheville is situated in Western North Carolina upon a hilly table land, at an elevation of 2,350 feet, in the culmination of the Alleghany Mountains, between the diverging ranges of the Great Smoky Mountains and the Blue Ridge.

Completely surrounding this plateau of some thirty miles in width, with the Blue Ridge to the south, east, and northeast, and the Smoky Mountains to the west and northwest, are the projecting spurs and peaks of these ranges with an elevation double and almost treble that of Asheville. The meteorological conditions of the plateau—the temperature, the purity of the air, and the amount of precipitation—are peculiarly influenced by these high mountain chains. The rain clouds, especially those approaching from a southerly direction, are saturated at a higher temperature than they meet on approaching and passing over these mountain ranges, and on that account they precipitate their moisture before reaching the plateau. In consequence there is a difference of from fifteen to twenty inches of annual rainfall, and from ten to twelve degrees in relative humidity, between places situated immediately in the surrounding mountains and the Asheville plateau.

In the winter season the temperature is moderated by the prevailing air currents from the south, but as they come as a rule from a northerly direction in the summer, the summer months are cool and pleasant.

Preferring not to make use of tabulated meteorological statistics which are difficult to decipher, and to be complete would occupy my entire available space, I may say that Asheville is practically an all-year resort, having, in the parlance of climatologists, a medium elevation, and offering favorable conditions for out-of-door life at all seasons of the year.

The Winter Months.—January and February present, however, periods of cold weather, lasting for a few days, and exceptionally for a week, and several of such "cold spells" are observed during these months.

Such a cold-spell is as a rule initiated with a considerable wind movement from the north, during which the temperature falls rapidly to 10° F. or to zero, and temperatures below zero have been observed during several of the twelve winters during which the writer has had charge of the local weather bureau. As already stated, these cold spells do not last, the wind subsides after from twenty-four to thirty-six hours, and then the temperature rises. The days are bright, and during the hours of sunshine invalids can be out of doors, when properly clothed, without suffering from cold.

The humidity averages between 50 and 55 per cent. in the two winter months, and the dry atmosphere and large amount of sunshine have a stimulating and exhilarating effect upon all cases which are otherwise in a condition to profit from climatic treatment. The amount of ozone in the air reaches its greatest proportion in these months, and 70 per cent., of a scale from 0 to 100, has frequently been recorded.

In some years the winters have been very mild, but frosts occur in the spring months as late as the latter part of April. Snow rarely falls, and when it does, it melts away under the sun upon the same day or within a day or two thereafter. The average snowfall is less than two inches.

The *spring season* has its beginning between February 20th and March 10th, during which the vegetation begins to spring up, and the trees to leaf out. The days are comfortable, and while not hot, temperatures up to 75° F., during the hours from 10 A.M. to 3 P.M., are quite common.

Thunder storms occur with the advent of such warmer weather, and are attended with brisk showers, especially upon the environing high mountain ranges, where one can often see such storms in progress while the plateau enjoys bright sunshine.

The relative humidity during the spring months averages between 60 and 65 per cent.

One of the features of the spring is the beautiful and varied flora of this region, and the azalea, laurel, and rhododendron, as well as the smaller flowers of the mountains, are the delight of all visitors.

The Summer.—In some years past June has been as warm as any of the summer months, and the highest maximum temperature may fall in this month or in July or August. The highest temperature recorded in the past twelve years was 91.3° F., but 90° F. is frequently reached during the summer of every year.

Usually there are cool breezes during the day, and unless one is exposed to the direct rays of the sun, there is no discomfort on account of heat. When the sun goes down the air cools rapidly, and the nights are always comfortable and bed covers are necessary, at least after midnight.

The rainfall during the summer months is, as a rule, greater than in the winter, and heavy rains of short duration occur more frequently. I have known an inch of rain to fall in the course of an hour or two, but the excellent natural drainage carries the water off quite rapidly, and the streets become dry in a few hours.

The average rainfall for the summer is four inches per month, and the average humidity varies between 70 and 75 per cent.

The Autumn.—With but few exceptions, in the twelve years of my experience, the fall weather has been continuously pleasant and enjoyable until January, when, as stated above, colder weather usually sets in. With frosts in October the foliage of the great variety of trees and shrubs begins to turn, assuming every possible shade and hue from the green of the pine, to yellow, crimson, red, purple, and brown, and this change goes on until December or even later, when the leaves begin to fall. Visitors never tire in their admiration of this ever-varied play of colors in the closely adjacent forests, and thousands of boxes of leaves and branches of myrtle, mistletoe, holly, and galax are mailed from Asheville during the fall and winter months to distant friends and relatives.

The fall months are always delightful, the temperature declining in average and maxima gradually; and after October 1st artificial heat is frequently required in houses in the early morning and evening.

The total annual rainfall is forty inches, and is nearly equally distributed over all the months, with a slight increase in summer. There is no distinctly rainy season or month, and no distinctly dry season for any part of the year.

Having given the essential information as to the climate, I may now consider other subjects which are of interest and about which inquiries are frequently made the by distant physicians and intending visitors.

The city has a permanent population of fifteen thousand and a floating population of several thousand more, the latter consisting of people who are in search of health and pleasure. The railway station is situated in the valley near the confluence of the French Broad and the Swanannoah Rivers, at a distance of a mile from the centre of the city, which is located on a bluff about three hundred and fifty feet above the river valley. The streets from the depot and in the central parts, as well as some of the residence streets, are well paved with brick, and brick pavement and macadam extend to Biltmore, a distance of two miles, to the Vanderbilt estate. Electric trolley lines connect the different parts of the city with the de-

pot and with Biltmore, and also extend to other suburbs, giving ample facilities and good service for all purposes. The business part of the city is well and substantially built, and the business establishments compare favorably with those of even larger cities either North or South.

Apart from its mercantile business, Asheville is practically a town of hotels and boarding-houses, and the available accommodations are ample in kind and good in quality according to the rates charged. As to the latter it must not be forgotten that provisions and fuel are more expensive than in thickly populated centres, which are nearer to their sources of supply and have low rates of transportation.

The rates in the cheaper boarding-houses vary from \$4 to \$8 per week, but most of these do not offer accommodations suitable for invalids. The better houses charge from \$10 to \$15 per week and give good accommodations. A few of them refuse invalids altogether, catering to well people and pleasure-seekers only.

There are several good commercial hotels in the centre of the city, with daily rates of from \$2 to \$3. These are suitable for a brief stay when one first arrives; but invalids should be advised to avoid such hotels for permanent quarters on account of the want of facilities for out-of-door life. The more fashionable hotels are the Battery Park and the Kenilworth Inn. The former is open all the year, and, though centrally located, it has large grounds and abundant piazza room, and is otherwise first class in all its appointments. It is the popular hotel in Asheville with the wealthier class of visitors.

The Kenilworth Inn is open only during the winter season, from the middle of January to May. It is situated near Biltmore, about two miles from the city. This is also one of the finest equipped modern hotels of the South.

A special institution for tuberculous patients was established over twenty years ago by Dr. J. W. Gleitsmann, now of New York. After it had been conducted for several years and had shown excellent clinical results, it was closed in 1883. The Winyah Sanitarium for tuberculous patients was established in 1888 and has been in successful operation since. New, modern, and perfectly appointed buildings and cottages were erected during 1899, and were opened for patients last January, and cottages with an aggregate of sixty private rooms for patients are in progress of construction, to be completed in the fall of 1900. With their occupation the old buildings will be abandoned. This institution is situated in a small wooded park of seventeen acres, in the outskirts of the city, and the electric car line passes through its grounds. The admissions are limited to such patients only as have a reasonable prospect for improvement and recovery, and, as far as there is room, accompanying friends can also obtain accommodations.

While there is no city hospital receiving all patients free, the Mission hospital has limited facilities for caring for the city poor, as well as for those who can afford to pay for private rooms. It admits no contagious diseases. Although small it is well equipped with modern appliances and is under the care of a staff of local physicians.

The water supply of the city is from the headwaters of the Swanannoah, and is perfectly pure, as shown by competent analysis and bacteriological examination.

The city, except in some of the negro quarters, is well sewered. Under the diligent labors of a competent board of health, the general sanitary conditions of Asheville have been much improved, and they are now as good as those of other progressive cities. Expectoration in public places and upon sidewalks is forbidden under fine; and the prospect for an ordinance requiring meat inspection, the testing of dairy cows for tuberculosis, as well as the disinfection of rooms previously occupied by tuberculous patients is good, and will probably be a law before these pages go into print. The mortality of the city is very low, especially among the white population; malaria is unknown, and phthisis among the natives is rare.

Asheville has a system of good graded schools, a military academy for boys, and several colleges for girls, and these private institutions are of a high standard and well conducted. Students from localities in which the climate is unfavorable to delicate and rapidly growing youths, and invalided parents who come to Asheville for permanent homes with their children, are offered excellent educational advantages.

Asheville has also a good public library.

The principal religious denominations are all represented and their church edifices would be creditable to a larger city.

Cottages and larger houses, furnished and unfurnished, are plentiful for rent, the prices varying from \$10 per month upward.

Many inquiries are constantly being received by the writer from invalids as to opportunities for employment. Most of the invalids who arrive here in quest of employment are physically unfitted for labor of any kind, and it is a great mistake to send to this or any other health resort phthisical patients who must depend upon their own exertions to make their way.

Sources for amusement and recreation are chiefly limited to driving, horseback riding, and walking amid the beautiful scenery of this region. Golf links, said to be among the finest in the country, baseball grounds, an opera house, and the gayeties of the fashionable hotels furnish their part in season.

Carriage hire and riding horses may be obtained in Asheville at very reasonable rates.

Asheville is on the Southern Railway, about half way between Salisbury, N. C., and Knoxville, Tenn. Through sleepers leave New York City over the Pennsylvania Railway via Washington at 4:30 P.M. and arrive at Asheville at 8:30 P.M. the next day.

Through sleeping accommodations exist also from Nashville, Tenn., and Cincinnati, Ohio, the trains leaving these cities at 8 P.M. and arriving at Asheville the following day in time for dinner.

There is also direct connection from New Orleans via Montgomery, Birmingham, and Atlanta; and the Southern Railway gives an excellent service over all its lines, taking special pains with its Asheville patronage.

Karl von Ruck.

ASPARAGIN.—$C_4H_8N_2O_3,H_2O$. A crystalline principle, obtained from *asparagus officinalis*. It also is very widely distributed in nature, having been found in almonds, licorice root, belladonna leaves, potatoes, lily of the valley, marshmallow, and many other plants.

It is neither an alkaloid nor a glucoside, but an organic principle derived from malic acid. When decomposed by strong acid, it is converted into ammonia and aspartic acid. It occurs in hard, brilliant, colorless crystals, with a faintly saline, cooling taste, soluble in water, one part in twelve.

The use of asparagus is being revived, and this principle is recommended as the best means of obtaining its therapeutic properties. It is administered in doses of one grain to one grain and a half three times a day.

Asparagus has long been supposed to possess therapeutic properties, but it has not received much attention. The roots and shoots are official in the French Codex, and at many European watering-places it occupies an important position in the articles of diet in lithiasis and in the treatment of gouty patients. It increases the flow of urine and imparts a peculiar strong odor. It may cause vesical irritation, and should be used with caution when the renal tissue is diseased. In cardiac dropsy it is recommended, as its action is said to resemble that of convallaria.

Beaumont Small.

ASPARAGUS.—The common garden asparagus, A. *officinalis* Linn. (Fam. *Liliaceæ*), will hardly be made more familiar by description. It is a native of Europe and cultivated everywhere. Both the underground portion and stems are official in France.

"Asparagus root," as the rhizome is improperly called, contains *resin*, *glucose*, *dextrin*, bitter extractive, and other simple constituents, but no *asparagin*. The

fresh sprouts have, in addition, the interesting compound *asparagin*, discovered in 1805 by Vauquelin and Robiques.

As a medicine asparagus is of little use. Its property of modifying the odor of the urine is known to every one, and is caused by methyl mercaptan, a decomposition product of protein. It may increase the quantity of urine excreted, but does not do so always. It appears to make it slightly irritating, and to prompt to more frequent micturition. In large doses, it has been compared, in its effects upon the heart, to digitalis, but is rarely now used with this in mind. (See *Asparagin.*)

W. P. Bolles.

ASPERMIA. See *Sterility in the Male.*

ASPHYXIA (*a*, privative, σφύξις, a pulse).—Diminution or suspension of the phenomena of hæmatosis and of the respiratory function from hindrance to the entrance of air into the lungs

Turned from its primitive sense, the word in medical technology, and even in common language, has now quite a different meaning, experiments having shown that the physiological fact, qualified summarily under the name asphyxia, may be the consequence of several pathological states, or of distinct functional troubles. Broadly speaking, there will be asphyxia when any obstacle whatever hinders air from penetrating the pulmonary vesicles, or when the fluid that penetrates them is of any other nature than the medium in which the animal is destined to live. Consequently the name asphyxia is applied generically to all accidental conditions in which life is threatened by any interception of the respiration which impairs the *quality* of the blood, but does not diminish its quantity.

Many writers, objecting to the term, advise its abolishment from medicine, and seemingly with good reason, since asphyxia may be confounded with apnœa, suffocation, syncope, shock, dyspnœa, and other disorders of respiration, and with suspended animation from various causes. On the other hand, it is preferable to retain this name rather than coin a new one, which in its turn may be inadequate to explain phenomena that may be subsequently revealed by science. Under the title are grouped many accidents or diseases that have no other relations between themselves than a gradual lowering of the hæmatosis, of the pulse, of the temperature, and of sensibility and motion.

Varieties.—Several conditions resemble or complicate but do not constitute asphyxia. *Apnœa*, or syncope of the lesser circulation, is physiologically opposite to asphyxia, since the stoppage of respiration is owing to the saturation of the blood with oxygen. *Apnœa* occurs when the blood is shut off from the air passages; *asphyxia*, when the air is shut off from the blood. Apnœa is *breathlessness;* asphyxia, difficulty of taking in breath. Poisoning by toxic vapors, the fumes of sulphuric acid, chloroform, mephitic gases in general, and more especially the gas produced by burning charcoal, do not occasion asphyxia, but a true poisoning, resembling narcotic poisoning, in which the oxygenation of the blood has no recognized part. Of the toxic gases, the disastrous inhalation of which is erroneously attributed to asphyxia, an exception must be made in favor of oxide of carbon. This gas acts by paralyzing the blood globules, and by obstructing the gaseous exchanges of which they are the agents. Between poisoning by the inhalation of toxic vapors and asphyxia there is this capital difference: in the pretended asphyxias the hæmatosis continues, in real asphyxia hæmatosis ceases. Asphyxiation by lightning and by vacuum, being of no practical interest, cannot be touched upon; and the complex state in which phenomena analogous to asphyxia are thought to occur in the fœtus, from impeded circulation of the placenta, does not appear to call for special mention in connection with our subject. *Infantile asphyxia*, or the apparent death of the new-born, is a distinct morbid condition brought on by a cerebral congestion, or by a syncopal state, and will be studied elsewhere. The term *local asphyxia* is rather a bold innovation that has been applied to symmetrical angio-neurotic gangrene of the extremities, as seen in Raynaud's disease and in the aborted form known as *digiti mortui*. Its supposed cause is privation of oxygen, but in reality it is due to embolic arrest of circulation in the parts affected, resulting from propathia or from lesion of the cord or its envelopes. *Secondary asphyxia* may occur after drowning or other cause of asphyxia. The individual having recovered from the primary effects of the asphyxia, dies suddenly, without apparent cause, after a lapse of a few minutes or several days. Such cases are explained as the secondary results of the arrested interstitial nutrition that took place during the period while breathing was temporarily arrested.

Phenomena.—Interruption or suspension of the respiratory phenomena may be influenced by diverse circumstances. It is a matter of common experience that nervous impulses from without act upon the respiratory centre in various ways. Cold water dashed on the skin affects the breathing, and of all the apsychical nerve centres, the one that controls respiratory events is, perhaps, most frequently and deeply affected by the action of the will and the emotions. When pulmonary absorption ceases, that is to say, when oxygen is diminished, and carbon dioxide is stored up in the blood and in the tissues, the rhythm and character of the respiration become changed by the venous blood mixture affecting the inhibitory nerves of the heart and the medulla oblongata, labored respiration follows, and this in turn gives place to dyspnœa and unconsciousness, which merge into asphyxia, and a fatal termination ensues unless some restorative event occurs.

Many of the modifications that occur in asphyxia have been noted in physiological experiments. The blood of an asphyxiated animal resists slow combustion and putrefaction; when the venous blood enters the deep tissues of the organs suppression of the urinary and other excretions follows; the glycogenic function of the liver is interfered with and, if the asphyxiation be sufficiently slow, the temperature is lowered. An excess of carbon dioxide in the blood excites powerful respiratory movements; while hyperoxygenation, or saturation of the blood with oxygen, checks the respiratory movements. Hearts of frogs, plunged in carbon dioxide, stop beating in about ten minutes, but continue to contract during more than three hours in air, and at least an hour in nitrogen gas. Hearts of new-born rats placed in tepid water, saturated with carbon dioxide, and others in ordinary water of the same temperature, show that those placed in the carbonized water beat much quicker than the others. It is demonstrated that the contractile power of the heart is preserved much longer in oxygen than in carbon dioxide. There is also a loss of muscular contractility, notably in the muscles that control defecation and micturition, and in females near the full term of pregnancy the fœtus is expelled. The pupils, at first contracted then dilated to the maximum, offer in the fibres of the iris a phenomenon of the same order; the expansion in this instance being consequent upon the irritation of the centre in the medulla governing the action of the pupil. In the diminished respiration from deficiency of oxygen lies the true cause of dyspnœa and asphyxia. No animal can maintain the respiratory process in an atmosphere devoid of oxygen, or in one that does not contain at least ten per cent. of this gas, and such quadrupeds as whales, hippopotami, and seals or the pygopodous birds would drown in the same manner as a dog if kept submerged long enough. It is mainly by virtue of the arterial plexus, known as the *retia mirabilia*, which stores up a supplementary supply of oxygenated blood, that these animals are enabled to remain so long submerged and resist asphyxiation.

Absence of the respiratory murmur in the chest, and abundance of mucous râles in the bronchi, always accompany asphyxia. Diminution of sensibility also comes on gradually, and, following an ascending and

centripetal march, appears last in the cornea. Progressive anæsthesia measures the degree of asphyxia, and absolute general insensibility indicates complete arrest of life beginning at the lungs. After all other movements have ceased the heart continues to beat, and finally stops in a state of diastole.

ETIOLOGY.—Asphyxia is one of the most frequent of the immediate causes of death. It may result from any of the causes that hinder respiration. These causes may arise from circumstances inherent to the individual, or they may be exterior to him. Asphyxia being brought about by the circulation of non-oxygenated blood in the lungs and the respiratory centre in the medulla oblongata, may be produced by any cause that tends to oxygen starvation and the accumulation of carbon dioxide in the blood. Arrest of the thoracic movements and hindrance of hæmatosis may sometimes be produced by any of the causes of thoracic spasm; by hemorrhage at the base of the brain or in the medulla oblongata, or by poisoning by curare; by the slow and gradual feebleness which precedes and leads to fatal disease; by the introduction of air into the blood, and by the action of cold or of heat.

Mechanical obstacles to respiration often bring on cyanosis and anæsthesia, resulting in arrested hæmatosis. Special instances occur in the case of arrest of respiration by a foreign body in the larynx, or by a polypus, by œdema of the glottis, by an abscess of the pharynx or of the tonsils, by a goitre compressing the trachea, by an accumulation of mucus in the trachea in capillary bronchitis, by an extensive pneumonia, by a considerable hydrothorax, by strangulation, by intestinal pneumatosis compressing the diaphragm into the thoracic cavity; by pressure on the chest, not capable of being overcome by respiratory efforts, such as the falling in of earth, being crushed in a crowd, or by the accident of overlying that often happens to young children, and by changes in the pressure of the air breathed, no matter whether this be a gradual diminution, a sudden diminution, or an increase. Asphyxia may also result from traumatic cause, as injury to the spinal cord or the base of the brain, a double wound of the chest admitting air, an opening of the diaphragm permitting the passage of the abdominal organs into the thorax, and from hemorrhage.

In the foregoing instances the air surrounding the individual does not present any alteration, the inspiratory efforts produce still some effect, but this effect is insufficient to preserve life.

Submersion in any liquid medium whatever causes asphyxia, and it may be caused by being surrounded by a medium devoid of oxygen and improper to support sufficient hæmatosis, as hydrogen, nitrogen, and the protoxide of nitrogen, gases not toxic, properly speaking, but considered irrespirable.

The three typical modes of asphyxia, the most important practically and the best studied in theory, occur in *strangulation, submersion*, and *confinement*.

In occlusion of the air passages from mechanical impediment, such as garotting, throttling, or by a noose or ligature, death results essentially from asphyxia. In some cases of hanging death may occur from asphyxia in combination with coma, the conjoint causes of occlusion of the air passages and disturbance of the cerebral circulation giving rise to the condition known as neuroparalysis. It is observed in a general manner that all kinds of death caused by the privation of respirable air have among themselves the greatest resemblance. Whatever be the obstacle that intercepts the connection of the lungs with the atmosphere, the apparent differences are only secondary, and the essential symptoms are identical, because all act in suppressing the functions of the blood and hæmatosis. In fact, the phenomena of asphyxia are constant, and related to disturbances in the respiration, innervation, and circulation, which vary according as the asphyxia is the result of submersion or of the absence of oxygen in the surrounding medium, according as it is immediate or slow. The fatal result of asphyxia is owing to the introductory arrest of the pulmonary circulation, the capillaries of the lungs being incapable of conveying venous blood. The stagnation of the blood in the lungs is followed by paresis of the respiratory centre and stoppage of the heart.

It is doubtful whether life be ever recalled in any case after stoppage of the heart following on asphyxia, yet the facts of suspended animation prevent the formulation of precise statements in this regard. Pigeons apparently dead from the effects of chloral hydrate recover, and fish frozen for a considerable time can be resuscitated by immersion in cold water. The writer has seen frozen terrapins resuscitated in the same manner. A striking difference is observed in dogs submitted to experiment. They recover after they have been deprived of air for three minutes and fifty seconds or even four minutes, but they die if they are submerged in water for a period of two minutes. They recover after two minutes and fifteen seconds if chloroformed before submersion. Dr. B. W. Richardson reports a case of recovery in a child with croup who was completely asphyxiated for eleven minutes, and cases of recovery from hanging are known in which the time was much longer.

Asphyxia, though not always the *mode of death* in those submerged, is commonly present in a certain number of cases. The resistance of new-born animals to this mode of asphyxiation is especially noted in the greater time required to drown a new-born pup than an adult dog. One minute and a half usually suffices to drown a dog, while a new-born pup often requires as much as fifty minutes. This great difference is owing to the less active change of tissues, and the smaller consumption of oxygen in the young animal. The more active the vital combustion, and the greater the demand upon the general store of oxygen in the blood, the quicker the young animal perishes when the respiration is obstructed.

Accidents owing to the absence of respirable air, or to confinement in places where the air is not renewed, are of common occurrence. Asphyxia from this cause is less prompt than that by strangulation. The phenomena connect and follow one another. Efforts to hold the respiratory function in abeyance are soon followed by head troubles, with nausea, loss of consciousness, diminution of the pulse, and insensibility of the skin. The more energetic the subject the more intense are the effects of asphyxia.

Although no warm-blooded animal can live in any medium not containing a sufficient mixture of oxygen, yet animals may become habituated to deteriorated air, and in certain conditions of suspended animation they may live for a certain length of time with impunity in a vacuum, and even in a medium charged with carbon dioxide. Rats and mice live in air containing but one, and even 0.5 per cent. of oxygen, and carnivora and birds resist death in an atmosphere in which the proportion of oxygen is so small as barely to support the combustion of a candle. There is also a tendency in the new-born to resist asphyxia from confined air. Young sparrows without feathers have been known to live twenty-four hours in a space where the adult sparrow died in two hours. Marmots in a state of hibernation live under an exhausted receiver, but die when awakened. Cold-blooded animals resist longer the privation of atmospheric air, as can be fully seen in the case of frogs.

It is sufficiently demonstrated that death in confined air is due, as is death in nitrogen, to simple privation of oxygen. Death from asphyxia may also occur in atmospheres which are still rich in oxygen, but in which the proportion of carbon dioxide is too high, as in caves, cellars, and the like.

The important facts relating to the cadaveric lesions, the treatment, and the medico-legal questions likely to arise in connection with asphyxia, will be found in the following article.

Irving C. Rosse.

ASPHYXIA, MEDICO-LEGAL RELATIONS OF.—

What is asphyxia? Nothing is more difficult than to express in a definition all that any medical or legal

term may mean. No proof of this assertion is required by the reader who sees how differently authors define the meaning of such terms, and how constantly the simplest definitions are varied, qualified, and amplified by the authors themselves.

Nor can the derivation of the word itself determine its present technical meaning, for it has long since acquired a meaning distinct from the meaning derived from the Greek, α, privative, and the verb, σφύξειν, to pulsate, without pulse, as all death is that.

The definition accepted by lexicographers is best stated in the Century Dictionary, as follows: Asphyxia, the extreme condition caused by lack of oxygen and excess of carbon dioxide in the blood, brought about by a sufficient interference with respiration, as in choking, drowning, or paralysis of the muscles of respiration.

In its medico-legal sense, asphyxia is the cessation of the heart's action which arises from interrupted respiration, caused either by expelling the air from the body or by preventing the entrance of pure air into the body. When air is eliminated from the body, or pure air prevented from entering the body, the action of the lungs is paralyzed, and the blood, no longer aërated, loses its vital qualities and circulating powers. The combination of these conditions causes death. Death so resulting is called death from asphyxia, and the condition produced by this combination is asphyxia.

While asphyxia in a certain measure produces general effects which are practically similar in character, yet, as above indicated, it is not always caused by similar agencies, nor does asphyxia always present symptoms entirely uniform. On the contrary, there are found in cases of asphyxia produced by different agencies strikingly different physical symptoms, both external and internal. For sake of illustration: in the cases of asphyxia resulting from suffocation, there is rarely any positive disarrangement of the vascular system of the brain, and ecchymoses are comparatively slight, and often unapparent to the untrained eye; while in the cases of asphyxia resulting from strangulation, the vascular system of the brain presents strong evidence of death by strangulation, the condition of hyperæmia being marked, and ecchymoses are, as a rule, much more pronounced in number and in extent, so much so as to challenge the observation of the unprofessional witness.

There have been almost as many divisions and subdivisions of asphyxia as there have been treatises devoted to the subject. However, for the purposes of this article, asphyxia may be divided as follows:

1. Asphyxia from the want of respirable air, and from the inhalation of noxious gases.
2. Asphyxia from suffocation.
3. Asphyxia from strangulation other than from hanging.
4. Asphyxia from strangulation from hanging.
5. Asphyxia from drowning.

In this article, however, asphyxia from drowning will not be discussed, as a separate article upon this branch of the subject will be found elsewhere in this work (see *Drowning*).

How Asphyxia May be Proven.—Without trenching too much upon that branch of medical jurisprudence which treats of the introduction of expert testimony, it is not amiss briefly to sketch the principles applicable to the admissibility of expert testimony in reference to asphyxia.

In such cases, in the administration of justice, it frequently becomes necessary to determine the nature and cause of physical injury and death. These questions arise in tribunals vested with the power to try civil causes and also in tribunals vested with the power to try criminal cases.

The judgment of human courts is fallible enough at all events, but it is evident that no judgment can be approximately just unless founded upon a true statement of facts. Recognizing this axiomatic truth, the administrators of the law recognize the further principle that in determining the nature and cause of physical injuries and death, they must look for help from that profession the members of which have devoted their time and talent to the study of the human body, its nature, and its infirmities.

The rules that are prescribed by the courts in securing the help of medical experts constitutes a large part of medical jurisprudence.

In questions arising from injuries and deaths from asphyxia, the courts exercise the function above mentioned, and summon to their aid medical experts.

The questions upon which these experts are to shed light are necessarily these: Was asphyxia the cause of the injuries or the death of the person; and second, if so, by what means was asphyxia effected?

These opinions, given by the medical witnesses, constitute expert evidence.

The law recognizes the value of such evidence (in many cases it is the only method of arriving at a just conclusion), but both the law and the science of medicine recognize the dangers of relying upon expert evidence alone, and usually it has its greatest weight when supported by collateral evidence.

The Lay Witness.—However, the law does not rely alone upon expert evidence, in arriving at the facts in a case of death supposed to have been caused by asphyxia; if it did, oftentimes justice would miscarry. Indeed, in the majority of cases it is necessary to have witnesses both lay and expert.

The physical facts, including the surroundings, the position of the body, its appearance after death, etc., are facts which may all frequently be proven as well by one of the commonalty of men as by the skilful scientist. To illustrate: Should the subject of investigation be whether or not the deceased died from strangulation, lay witnesses would be permitted to testify as to the position in which the body was found, the marks of violence upon it, the prints of fingers or marks of hands, the discoloration of the skin, the protrusion of the tongue, etc. But they will rarely, if ever, be permitted to give opinion as to whether or not the deceased was strangled to death.

In a great number of cases, the lay witness is very valuable and sometimes is indispensable. He is indispensable when no physician viewed the body after death. In such a case, without lay testimony, the expert opinion is necessarily useless, having no physical facts upon which to base an opinion.

Nevertheless, the legal profession recognizes the danger of determining the cause of death from asphyxia, when the physical facts upon which the expert opinion is based are derived entirely from lay witnesses. The justness of this can be readily appreciated when it is considered how easily the lay witness might fail to discover some physical sign which would readily appear to the medical expert, and have the effect of compelling a radically different opinion as to the cause of death.

The Expert Witness.—The testimony given by the expert witness is twofold; first, it is purely opinion evidence, based upon hypothetical questions. When such evidence is permitted to be given, the hypothesis submitted to the expert must be made up of facts testified to by other witnesses.

The opinion, therefore, of the witness can have no weight with the court, unless the facts upon which it is based are accepted by the court as the true facts of the case.

But the expert witness is not confined to purely hypothetical questions where he has made a personal examination of the body And in a case of asphyxia, the expert, having examined the body, will be permitted to testify that in his opinion death was or was not caused by asphyxia, and by what means he believes asphyxia was effected.

Upon cross examination it may be elicited as to how carefully his examination was made, and the witness can be compelled to give in detail his reasons for his conclusions.

The student will readily conclude that in preparing to testify as to whether or not a death was caused by as-

phyxia, great care should be taken. In fact, before one is really competent to pass upon such a question, he should be learned and experienced in medicine. He cannot hope to be able thoroughly to prepare himself by the study of works upon medical jurisprudence alone.

Starting with the proper foundation of professional accomplishments, it is well for the witness to freshen his mind upon the minutiæ of the subject, and if called to respond to hypothetical questions alone, this will be doubly essential, for the witness may expect a rigorous cross examination, often conducted by an adroit advocate, coached to the edge by some accomplished medical expert.

If, however, the witness has had occasion to examine the body and its surroundings, and proposes to testify as to the cause of death based upon his own personal examination, he will find that he will require accurate information not included in his science. He will be expected to have a distinct recollection of the surroundings and of every detail of the physical appearance of the body, internally and externally. For this reason, whenever any substantial doubt exists as to the cause of death, and especially where crime is suspected, the physician should by all means make an autopsy.

On such occasions memory should not be trusted too far, and copious notes should be made by the physician concerning the surroundings, and especially concerning the results of his physical examination

The extent of his ability as physician will tell him best what to look for and what to make note of, in regard to the condition of the body, and his knowledge of medical jurisprudence will prompt him to decide what facts concerning the position of the body, etc., he should preserve.

Having progressed thus far, it now remains for me briefly to discuss the four divisions of asphyxia which it is the province of this paper to treat, namely: (1) Asphyxia from the want of respirable air and the inhalation of noxious gases; (2) asphyxia from suffocation; (3) asphyxia from strangulation other than from hanging; (4) asphyxia from strangulation from hanging.

(1) *Asphyxia from the Want of Respirable Air and the Inhalation of Noxious Gases.*—Doubtless this division of the subject embraces what is more commonly understood to be asphyxia. In this division are included such instances as where the asphyxiated person has been shut in a small apartment with no means of receiving fresh air; instances of death in which the illuminating gas is blown out, or turned on in the room, when the victim was asleep; instances in which unfortunate miners meet the fatal damp of the mines, or unfortunate laborers perish in sewers by reason of being overcome with what is known in the popular vernacular as "sewer gas." And the books do present instances of death coming to one who was keeping guard over flowers which exhaled a poison in their perfume which was deadly to the watcher.

The three most common ways by which death is caused by this class of asphyxia are as follows:

(*a*) There is a certain amount of oxygen in all pure healthy air. When this air is taken into the lungs a part of this oxygen is exhausted, and the air is expelled from the body, charged with a poisonous gas, called carbonic acid gas. Whenever the air becomes charged with this gas to a certain percentage further inhalation is deadly. Deaths occur usually from this cause when a large number of people are placed in a small, ill-ventilated room or apartment.

(*b*) This same poisonous gas frequently destroys life by being generated in a room where the victim is sleeping, in a most unexpected manner, as from the combustion of charcoal, coke, or anthracite coal. Sometimes it is turned directly into the room from a defective gas pipe or an open burner.

(*c*) Asphyxia is often produced by inhaling another noxious gas, even more deadly than the carbonic acid gas, and that is sulphureted hydrogen gas—commonly called sewer gas—which is most frequently found in sewers or the vaults of privies.

In the investigation of the cause of death, where asphyxia from noxious gases is supposed to be the agency, the first proceeding should be to discover, if possible, the presence of the gas in the air, and then to trace it to its source. If this can be done, it requires, as a rule, little skill to determine that the gas was the cause of the death; although it is possible that a dead body may be found in the midst of such poison, and yet death have arisen from another cause, as when murder has been committed and the assassin turned on the gas to hide his crime. It is also frequently the case that death ensues from such a small charge of the poisonous gas as to render its detection difficult. In such cases, and in cases in which the expert does not visit the scene of death, he must rely mainly upon the signs and evidences upon the body in arriving at his conclusion as to the cause of death.

The usual signs pointing to such death are swollen head, face, neck, and abdomen, jaws firmly set, discolored lips (dark blue), abdomen often violet-colored. The body preserves its warmth, especially when poisoning results from carbonic acid gas, for some hours, and the rigor of death is tardy in setting in, although these indications are frequently not all found in one case.

When death has not ensued, the physician will find, when the patient is suffering from carbonic acid gas poisoning, a disposition to sleep, a rapid losing of strength and sensibility, heavy breathing, accompanied at times with frothing at the mouth, and occasionally with delirium and convulsions.

When the patient is asphyxiated with sewer gas, nausea and irregular respiration, rather than labored respiration, agitated pulse, cold skin and loss of motion, frothy saliva tinged with blood, and closed eyes, are commonly accepted symptoms.

(2) *Suffocation.*—Following the definition in Wharton and Stillé's work on "Medical Jurisprudence," suffocation may be said to ensue when, "by any means air is excluded from the larynx or chest, or the chest is prevented from receiving it."

Suffocation is most commonly accomplished in two ways:

(*a*) By expelling the air from the lungs, by pressure upon the abdomen and chest, and by such continued pressure preventing the physical action necessary for respiration. Cases of this kind are more usually found where small children have been overlaid by older persons during sleep, and occasionally where one has been caught in a jam of heavy material, or pressed excessively in a great crowd.

Death in such cases is attributed to the fact that pressure upon the abdomen and chest compresses the vital organs, expels the air from the lungs, and so closes the lungs and windpipe as to prevent other air from entering. Death of this character usually results from accident.

Beck reports the case of a child who died from being wrapped up too closely by the parents, when it was being taken to a nurse.

(*b*) By covering the mouth and nostrils so as to prevent the ingress and egress of air, most frequently accomplished by the use of bedclothes, or other heavy clothes, a method made famous among all English-speaking people by the genius of Shakespeare, who makes his Moorish hero adopt it as a means of revenging his imagined wrongs upon the innocent and beautiful Desdemona.

In this division should also be included those cases in which the victim has been covered by dirt, ashes, snow, or the like, as by being buried alive or caught under a slide of snow. And in the same connection should be mentioned those cases in which feeble or intoxicated persons have fallen face downward in snow or sand or other similar substance, and, being unable to rise, have been suffocated.

Suffocation is not often adopted as a method of suicide, and it is infrequently resorted to for the purpose of homicide. Perhaps it more frequently occurs by accident.

Unless some facts are proven which point to the cause of the death, the expert is at a great disadvantage in attempting to determine whether or not death was due to external cause, or was the result of apoplexy, faucial disease, or pulmonary congestion.

Some of the most common physical indications of death by suffocation are lividity of the face and sanguineous engorgement of the viscera of the thorax and abdomen. There are frequently bloody infiltration of the eyes and eyelids, and very small ecchymoses of the neck and chest; a partial engorgement of the lung; little, if any, blood in the left ventricle of the heart, while the right ventricle of the heart is generally engorged. Sometimes a reddish froth is found in the trachea and bronchiæ. As a rule, the body is slightly if at all discolored, and the vascular system of the brain shows rarely any evidence of disorder. One of the most common indications is congestion of the kidneys. When a dead body is found in earth, ashes, or snow, or the like, the question presents itself at once whether the death preceded the fall or the burial. Perhaps the best-recognized test is to examine the stomach, gullet, and air passages. If the foreign matter is found in the stomach or in the gullet, this is regarded as very positive evidence that death followed the fall or burial, as only by the action of a body instinct with life could the foreign matter be so drawn in. On the contrary, if the foreign matter is found only in the nostrils and mouth, this is positive evidence that death was not caused by suffocation.

Suffocation frequently is caused by foreign substances becoming lodged in the windpipe or in the œsophagus. Children and infirm people more frequently suffer in this way. This often makes it necessary, in order to determine the cause of death, to make an examination of the windpipe and gullet, frequently by incision.

(3) *Asphyxia from Strangulation Other than by Hanging.*—The first question to be determined in this division is, of course: Was death caused by strangulation, and if so, by what means? Under this head we shall consider the indications of strangulation other than that accomplished by hanging.

As in all cases of asphyxia, the trouble in strangulation is the lack of air in the body. But the means used to create this lack is, in strangulation, different from the means employed in either of the two preceding divisions.

In strangulation, the access of air into the lungs is interrupted by a pressure upon the windpipe at the throat. This method provides a double means of death, and in the majority of instances death is the result of combined causes, namely, the lack of breath caused by the pressure upon the windpipe and the closing of the larynx, and congestion of the brain caused by pressure upon the veins of the neck. Either of these might be, in itself, sufficient to cause death, according to the violence of the attack, but it is rarely the case that the expert can definitely proportion the responsibility.

In the majority of cases, there are many apparent physical signs that point with great clearness to the cause of death, and give great aid in arriving at a proper conclusion.

Some of the physical indications that tend to lead to the conclusion that death has resulted from strangulation may be enumerated here. One of the most common indications is the presence of ecchymoses upon the face, neck, and chest caused by extravasated blood. The presence of these ecchymoses points strongly to death by strangulation, although it is usually conceded that the absence thereof will not be conclusive proof to the contrary. Frequently these ecchymoses are so minute as to fail to attract the attention of the lay observer, and for this reason a careful examination by the medical expert is often invaluable.

An examination of the brain will disclose more or less congestion and disarrangement of the vascular system generally, and congestion of the kidneys and liver is very common.

Aside from these indications, the swollen face, often the protruding tongue and eyes, and the distortion of the features generally throw much light upon the subject.

As strangulation other than by hanging is usually homicidal, great attention should be paid to noting any mark of violence upon the body, any evidence of struggle either upon the body itself or upon the surroundings. The condition of the clothing may be strongly indicative of attack and resistance.

Death from manual strangulation may be accomplished by means of the hands, cord, or other ligature.

When the hands are used, it is very easy, as a general thing, to determine that the strangulation was manual; but when a cord or ligature was used, the conclusion cannot be so safely or easily arrived at. In such cases, the mark of the cord or ligature will give aid. Where the strangulation was manual, as distinguished from strangulation from hanging, the mark of the cord will be very nearly horizontal, whereas in strangulation from hanging, the mark will be higher on one side than on the other, and will at the point of the knot approach near the head. The mark of the cord or ligature in manual strangulation is also, as a rule, much lower on the neck than when the strangulation results from hanging, as the weight of the body invariably causes the cord to slip as high as possible, only being stopped, as a rule, by the head.

There are seldom (in manual strangulation) any injuries to the vertebræ, and the ligaments of the neck are rarely torn; while, on the contrary, such results are frequent when strangulation is caused by hanging.

And, finally, it may be observed that in manual strangulation the throat is rarely so perfectly closed as in strangulation from hanging, for the suddenness of the fall, combined with the weight of the body, tends thoroughly to shut all the air passages. While the position of the body usually throws some light upon the question, yet this is by no means decisive, for it is an easy matter for the assassin, after accomplishing murder by manual strangulation, to suspend the body by a cord in order to cast about the death the appearance of suicide. The foregoing signs are merely helpful, and rarely unconnected with collateral evidence entirely satisfactory to the conscientious administrators of the law.

Human experience has demonstrated that few signs of this nature are to be absolutely relied upon, for oftentimes incidental and accidental physical facts tend to incriminate an innocent man, and frequently the guilty deliberately make evidence of this character in a speedy and skilful manner for the purpose of creating the impression of self-murder.

The importance of a careful investigation and physical examination is very apparent, when it is considered that while the law takes great care to punish the destruction of human life, it also takes greater care that no innocent man shall be punished. To such a degree is this carried that if from the evidence the jury should have a reasonable doubt as to the fact that the death was homicidal, under the instructions of the court an acquittal is necessary.

(4) *Asphyxia from Hanging.*—In determining whether or not death was caused by hanging, either when the dead body is found suspended or when it shows certain external evidences of such a death although no longer suspended, many of the evidences found in death from manual strangulation should be considered and sought for.

The congestion of the brain and the derangement of the organ in other respects are largely alike in the two forms of asphyxia, although more pronounced in death from hanging; the ecchymoses are also in evidence again, usually in a more pronounced manner, and the same physical distortions and swellings of the face and neck will be found, save, as in the congestion and ecchymoses, to an accentuated degree. But to the unskilled observer these indications may be said to be similar in death from hanging and in death from manual strangulation. After having observed these indications, which are largely alike, as just set forth, it is probably best to look carefully for those marks which

are common in both cases, but different in form or degree. The first should be the mark of the cord. In hanging it will be found not to be horizontal, one side usually being much higher and terminating in something like a point; the mark, furthermore, is invariably higher than in manual strangulation, the weight of the body drawing downward and forcing the cord to the base of the head, while the air passages are closely shut by virtue of the weight of the body or the sudden force of the fall. The marks of the cord are usually deeper and more distinct, and there will rarely be the same evidence of finger marks upon the face and throat. There are more pronounced excoriations in connection with the marks of the cord. The great majority of deaths from hanging are due to the combined causes of asphyxia and apoplexy; while in manual strangulation, perhaps a majority of deaths ensue from asphyxia alone.

One of the most common physical evidences found upon a body when death is attributable to hanging consists of injuries to the ligaments of the spinal column and the tearing of the carotid arteries in the neck.

The lens of the eye is said to be often cracked by the sharp shock of descent, and this sometimes gives help to the expert, if he is prepared to make a proper examination.

The effect upon the genital organs of both the male and the female victim often throws great light upon the question. It is mentioned by the authorities that hanging causes a certain excited condition of these organs both in the male and female, but usually more pronounced in the male. However, evidences of this are not always present, and in view of the fact that often they are found after death from other forms of violence, they alone will not suffice to prove that death was caused by hanging.

The usual effect upon the male genitals is a state of tumefaction; spermatozoa are found in the urine and in the urethra, and frequently there is an emission of semen. In the female, there is often found a dilated and inflamed condition of the genitals, and sometimes a bloody discharge.

Another indication commonly observed is the discharge of the bowels.

As many deaths resulting from hanging are suicidal, it is often a question of grave importance to determine whether the hanging was in fact suicidal or homicidal. It is the unanimous opinion of those who have made profound study of this subject that in the absence of collateral evidence the presumption is that the death was suicidal.

Hanging is such an easy and convenient method of exit from the world that the wretched and despondent frequently adopt it, in ridding themselves of those "ills they have." This is probably due in a certain measure to the fact that unlike many other methods of suicide, hanging, when once begun, can rarely be stopped by the would-be suicide. The first compression of the air passages tends to benumb all sensibilities, to stupefy the will, and to paralyze those other members of the body which, upon a change of mind, would be necessary to effect a self-rescue. Therefore, doubtless, in many instances in which the resolution to destroy one's self is only partially fixed, when the first step has been taken there is rarely an opportunity to go back.

Hanging can be accomplished in so many ways, and with such simple appliances, as also to present a royal road to death to the melancholy and desponding.

The main things to consider in this connection are: the position of the body, whether it swings clear or barely touches the ground; whether the hands and feet are bound; whether or not the cord or other device gives evidence of being prepared by another; and sometimes the manner in which the knot is tied.

There is no doubt also, as a rule, that in suicide there are no marks of violence upon the body, and rarely any evidence that would tend to show struggle.

But, in the end, evidence purely expert and hypothetical, in this as in all methods of determining the cause of injury and death, is to be received with caution, and is most valuable when considered together with proven facts that point to a cause of the death.

John Bell Keeble.

ASPIDIUM. See *Male Fern.*

ASPIDOSPERMA.—QUEBRACHO. *White Quebracho.* "The bark of *Aspidosperma Quebracho-blanco* Schlechtendahl (fam. *Apocynaceæ*)" (U. S. P.).

This plant is not to be confused with the quebracho Colorado (red quebracho), the wood and bark of which are very largely employed for the preparation of an extract used in tanning, and pertaining to the *Quebrachia Morongii* Britton (fam. *Anacardiaceæ*). The title "quebracho" means axe-breaker, and is, for obvious reasons, applied to various trees. In the last-named species it is the ironlike wood which has given the name. In that under consideration, it is the great abundance of stone cells in the bark which, occurring in masses, chip out the edge of the axe. The tree is of medium size, widely spreading, evergreen and handsome, and inhabits the northwestern portion of the Argentine Republic and adjacent countries. The supply of bark is irregular, and it is usually scarce and dear. It occurs in irregular chiplike or blocklike pieces, and is about the thickest and roughest bark of commerce, resembling only dita bark in this particular. The gray outer surface is most coarsely and deeply fissured, while the texture is so compact and tough that there is little tendency for it to scale off. Half the thickness or more consists of cork and cortex, the latter filled with large groups of stone cells. The color of this layer may be either of a yellowish white or pale yellow, or more or less rusty or brick red. The inner bark consists of several thick layers of very coarse bast fibres and varies from nearly white to a rather dark brown. It is very compact, tough, hard and woody, and of splintery fracture. All parts of the bark have an intensely bitter taste. The variation in the color of the bark cannot be explained in the present state of our knowledge. It is not the darkening of age, as the writer has bark which has been kept for many years, but which is almost white throughout. It is not improbable that a number of closely related species are in use. If so, the matter is in much need of investigation, as the composition and properties may differ more than the physical characteristics of the bark.

Composition.—Although aspidosperma contains, along with a small amount of tannin, no less than six alkaloids, its action is remarkably simple, owing to the fact that the alkaloids agree rather closely in their general action. *Aspidospermine, quebrachine, quebrachamine,* and *aspidospermatine* are crystalline, *aspidosamine* and *hydroquebrachine* are not.

Properties.—Their combined action is first to stimulate, then to depress the respiratory centres and to produce a nauseating expectorant effect, followed by muscular depression or weakness, including moderate cardiac depression. Abnormal temperature may be reduced. The drug, used in moderate doses, thus becomes capable of increasing both the number and the depth of the respirations, and of relieving spasmodic conditions, while in large doses it induces convulsive breathing and ends in fatal respiratory paralysis. Vomiting very rarely accompanies the nausea. It is said that aspidosamine, used alone, acts as an emetic. Little has been done therapeutically with the individual alkaloids, that usually sold as aspidospermine being an alkaloidal mixture. Neither has the therapeutical use of quebracho in any form been greatly developed. It is said to be used in its native home partly as an antiperiodic, and partly, like coca, to overcome the dyspnœa of mountain travel. Its chief use in professional medicine is to relieve the dyspnœa of asthma and other spasmodic conditions, as well as of emphysema. Owing to its weakening effect upon the heart, it is contraindicated in case of organic disease of that organ. The results of its continual use have not been found satisfactory, being those of continued depression of the nerve centres, with salivation and nausea.

A peculiar effect has been reported, in some cases, of promptly curing erysipelas by the hypodermic injection into the affected part of a half-grain of commercial aspidospermine. The dose of aspidosperma is 1 to 4 gm. (ʒ ¼ to 1). There is an official fluid extract, but the extract, in five-grain doses, is more often employed.

H. H. Rusby.

ASPIRATION.—In a paper presented to the French Academy of Medicine, November 2, 1869, Dr. Georges Dieulafoy brought to the notice of the profession a valuable method of detecting the presence of fluids in, as well as of removing them from, various parts of the body. The process is called pneumatic aspiration, or simply aspiration. Briefly stated, it is a method of exploring diseased parts with a hollow needle, connected with a vacuum, or, as it is called by the inventor, a "previous vacuum."

INSTRUMENTS.—While several different patterns of aspirator have been devised and recommended, only two require notice here, as they comprise the principal advantages of each of the others.

FIG. 364.—The Dieulafoy Aspirator.

The Dieulafoy aspirator (Fig. 364) consists of a glass syringe holding three or four ounces, and having two outlets at its lower end, each of which has a stopcock, *B, B;* a rubber tube, into which is let a glass index, *E;* and four needles of various sizes. The apparatus is used as follows: The needle having been connected with the syringe by means of the tube, and the outlets closed, the piston is withdrawn to its full extent, and secured by a quarter turn. The needle is now to be introduced at the proper place, and as soon as its point is buried in the tissues the corresponding cock is to be opened, thereby extending the vacuum to the extremity of the instrument. The needle is carefully pushed forward as far as is desirable, or until fluid is found, which will be indicated by its appearance in the index, if not in the syringe. The latter may be emptied by closing its outlet leading to the tube, opening the other, and unlocking and driving the piston home. Another vacuum is to be made as before, and the process may be repeated indefinitely without removing the needle or disconnecting the syringe.

Should the needle become stopped up during the operation efforts may be made to clear it by reversing the action of the syringe, and forcing a little fluid back, or it may be partially withdrawn, or carried a little deeper, or its direction may be changed. These manœuvres failing, it must be taken out, cleared, and introduced in another place.

With this instrument, stimulating or other liquids may be injected into a cavity by filling the syringe with the fluid, instead of exhausting the air.

Potain's aspirator (Fig. 365 *) comprises an air pump, *A*, having two openings, *C, D*, each of which is supplied with a metallic valve, working in opposite directions, the former allowing an exit, and the latter an entrance, of air to the pump; a bottle, with a capacity of a pint or more, fitted with a rubber stopper, *B*, which is perforated by a double metallic tube, whose outer portion terminates in two branches, each having a stop-cock, *K, L;* two rubber tubes, with the necessary needles, complete the apparatus.

* Codman & Shurtleff, Boston.

It is made ready for use by connecting the bottle with the needle by the indexed tube, *E*, and with the pump by the tube, *G*. The cock, *K*, nearest the pump, is opened; the other is closed. The air is exhausted from the bottle by a few sharp strokes of the piston, and the cock, *K*, is closed. The puncture is now made, and as soon as the point of the needle is under the skin the corresponding cock, *L*, is to be opened, and the exploration carried to completion. Another vacuum is readily established without disturbing the needle or its connections.

By attaching a rubber tube to the inner end of the metallic one, long enough to reach to the bottom of the bottle, and by changing the tube *G* from *D* to *C*, so as to force air into the bottle, instead of exhausting it, the apparatus may be used for injection or irrigation, or the bottle may be emptied of its contents by simply working the pump. This action is due to the fact that the inner orifice of the tube *K* is on the side just below the stopper, and hence independent of the tube in the bottle.

As a more perfect vacuum can be obtained with Dieulafoy's instrument, it is the best one for diagnostic purposes. It is also well suited for evacuating or injecting small quantities of fluid, especially when it is desirable to be exact as to the amount. But for drawing off large effusions, or for irrigating large cavities, Potain's apparatus saves time and labor. And it may be said that for general use the latter instrument is the more serviceable of the two, as it can be made to do the work satisfactorily in most of the cases requiring this operation.

The peculiar feature of the aspirator, which distinguishes it from the suction trocar, and which makes it so much more valuable, lies in what Dieulafoy calls the "previous vacuum." As this extends to the point of the needle the operator is notified of the presence of fluid the instant it is reached, and therefore there is little danger of passing through a small collection of fluid without knowing it, or of wounding deeper structures unnecessarily, a matter of much importance in tapping joints and other cavities. The strong suction power of

FIG. 365.—Potain's Aspirator.

this instrument enables one to use smaller needles, as well as to evacuate fluids which are too thick to be withdrawn with an ordinary trocar.

The aspirator should always be tested just before it is used upon a patient, because, from its peculiar construction, it is very liable to get out of order. The piston gets loose, the needles are easily plugged with rust or dirt, the tubes crack and break, the cocks stick, the stopper may not fit the bottle. All of these points require attention in order to avoid embarrassment and delay.

It would be well if all aspirator needles were made after the pattern recommended by Dieulafoy, namely, Nos. 1, 2, 3, and 4, having the respective diameters of 0.5, 1, 1.5, and 2 mm. ($\frac{1}{50}$, $\frac{1}{25}$, $\frac{1}{18}$, $\frac{1}{12}$ inch). After having been used, the needles should be thoroughly cleansed with hot water (carbolized), dried, and threaded with a wire to keep them patent.

Small trocars can be used with the aspirator in place of the needles for purposes of evacuation and irrigation.

For diagnostic explorations they are inferior to the needles, from the fact that with the former it is impossible to make use of the previous vacuum. The trocars are of special value in tapping the chest, or any other cavity in which there is danger of doing harm by the point of the needle.

In aspirating the cranium, pericardium, spina bifida, and intestine the smallest needle, No. 1, should be used. For the bladder, joints, strangulated hernia, and tumors, No. 2 is suitable; while for abscesses, thoracic and peritoneal effusions, the larger sizes are appropriate.

Owing to the fineness of the needle, and to the elasticity of the tissues, almost any organ or part of the body may be safely explored with the aspirator. For example, the head, chest, stomach, liver, gall bladder, spleen, intestines, uterus, tumors of various descriptions, and aneurisms have been punctured without untoward results. The principal diseases, however, in which the aspirator has been proved by experience to be of especial value are the following:

Retention of Urine.—In the severer stages of this affection, aspiration, as a temporary resource, is often of great service. It is safe, speedy, and effectual. So little pain attends the operation that, as a rule, anæsthetics are not required. If relief is not obtained in these cases from milder measures, together with a moderate trial of the catheter, it is far better to aspirate the bladder above the pubes than to irritate and perhaps lacerate the urethra by prolonged and often fruitless efforts at catheterization. The operation is best performed with Potain's apparatus. It being in readiness, the needle is entered on the median line just above the symphysis, and carried backward and downward toward the hollow of the sacrum, to such a depth that the point will not escape as the bladder contracts. When the viscus is nearly emptied the patient is apt to experience a pricking sensation, which is due to the needle's impinging on the posterior wall. It should be withdrawn a short distance, and the urine allowed to escape as long as it will without producing too much pain. The puncture in the skin may be covered with a bit of adhesive plaster. This operation can be safely repeated as often as may be necessary for two or three days, by which time the urethral irritation is generally so far subdued by appropriate measures that the power of voluntary micturition is restored, and the primary obstruction can receive the required attention.

Aspirating the bladder is preferable to the operation of tapping by the rectum, because it is safer, it is more easily performed, there is less liability to mistakes, and it is not followed by recto-vesical or other fistulæ, by extravasation of urine, or by pelvic or prostatic inflammation and suppuration, accidents which have occasionally supervened upon the rectal operation.

Affections of the Joints.—While almost any large joint containing a considerable quantity of fluid may be aspirated, the operation is chiefly confined to the knee. Large effusions in that articulation, whether of serum, blood, or pus, can be safely and quickly removed by this method. The needle is to be inserted wherever the swelling is most prominent, which is usually above or to the inside of the patella. Care should be taken not to wound the cartilages with the point of the instrument, as serious results have been known to ensue. After the operation the patient should be kept in bed, the limb should be placed upon a posterior splint, and firm pressure should be applied by means of flannel or rubber bandages. Should the fluid reaccumulate the operation may be safely repeated (under aseptic precautions) as often as is necessary. Anæsthetics are required only in children, and in nervous or timid subjects.

Strangulated Hernia.—It was thought at one time that aspiration might prove to be very beneficial in the treatment of this affection, but it has not stood the test of experience. The needle is apt to become clogged, or from various causes the tumor cannot be sufficiently reduced by this means to enable it to be returned to its proper place. It is true that many cases of successful reduction of the hernia after aspiration have been reported from time to time, but as the operation oftener fails than succeeds it is less frequently resorted to at present than it was formerly. Fatal results have followed this procedure, yet, when carefully performed with a No. 2 needle, it is attended with little danger, and it is occasionally successful.

Abscess.—Aspiration is frequently of the greatest value in determining the presence and character of fluids, but as a method of treating ordinary abscesses it is far inferior to free incisions, drainage tubes, and antiseptics. The pus usually reaccumulates after each evacuation, until finally a spontaneous opening takes place, unless it is anticipated by an artificial one. Occasionally, however, a favorable result follows repeated aspirations, as occurred in the case of an extensive pyæmic abscess over the sacrum, in the practice of a colleague. It was aspirated twenty-one times in twenty-five days, twenty ounces of pus being withdrawn at the first operation, and three ounces of serum at the last. But such cases are probably best treated by the method of incision, as above mentioned An exception to this rule is an abscess occurring in a person the subject of the hemorrhagic diathesis. Such cases, when active interference is necessary, should be aspirated rather than incised, as the hemorrhage would be less, and probably could be more easily controlled. Hepatic, perinephritic, and some other deep collections of pus may occasionally be treated by repeated aspirations. The diagnosis is thus rendered certain, the shock of the operation is less than that which follows incision, and in a certain proportion of cases a favorable result will be obtained.

Hæmatoma.—Collections of blood in the cellular tissue resulting from contusion or other injury may often be satisfactorily treated by aspiration, one or two operations being sufficient in many cases to effect a cure. A large needle or trocar may be used to evacuate the contents, and firm pressure should be applied to prevent a return of the affection. The withdrawal of effused blood by this method is much more successful than the evacuation of pus, and seldom does harm.

Pleuritic effusions can be readily drawn off with Potain's aspirator. It is better to use a trocar than a needle in these cases, as by so doing there is less danger of injuring the lung. The puncture may be made in the eighth or ninth intercostal space, about two inches below the angle of the scapula. The operation should cease the instant pain or coughing sets in, but it may be repeated as often as necessary. Should the fluid reaccumulate less rapidly after each evacuation, and the general health improve or at least remain good, a favorable result may be expected by persisting in the treatment.

It is the opinion of many who have had a large experience with this operation, that ether should seldom, if ever, be given during its performance. A number of fatalities have resulted from this practice. The pain is neither severe nor of long duration. Children may be restrained by moderate force, and adults seldom request an anæsthetic if the danger is explained to them. Should it be thought necessary to administer ether, a few whiffs, just enough to produce primary anæsthesia, is sufficient, and is much safer than complete etherization. But the rule should be, use no anæsthetics in tapping the chest.

The *pericardium* may be safely aspirated with the smallest needle, as follows: The puncture is to be made in the fourth intercostal space, one inch (2.5 cm.) from the left border of the sternum, and the instrument carried slowly backward, upward, and a little toward the median line. The puncture may also be made in the fifth interspace, an inch and a half to the left of the sternum. To avoid wounding the heart it is important that the vacuum should extend throughout the needle at the earliest moment possible. Little danger need be apprehended, even if that organ is touched with the needle. The latter should immediately be withdrawn under these circumstances and introduced in another place. Aspirating the pericardium is an operation that will not often be required.

Should it be deemed advisable to evacuate the fluid in

ease, but a complex of symptoms dependent on an anomaly of refraction. (See *Hypermetropia.*)

Hypermetropia may be briefly defined as a structural anomaly in which the refractive power of the eye, in a state of rest, is insufficient to focus parallel rays upon the retina. In the highest grades of hypermetropia, the total accommodative power of the eye (absolute range of accommodation) may be inadequate to meet the requirements of distinct vision, even at a distance, and the condition may then bear a superficial resemblance to amblyopia; but in the medium and lower grades there is ordinarily developed a state of habitual tension of the accommodation, under which the adjustment for distance, and in many cases for the near also, may be easily and unconsciously performed. In other cases, little or no inconvenience is felt in distant vision, but the greater exercise of the accommodation required for reading or other near work is felt to involve effort, and becomes wearisome. The fatigue in accommodation for near objects does not, however, imply an actual insufficiency of the accommodation for the work imposed upon it, for the position of the absolute near point (p) in youthful hypermetropes is, in most cases, well within the distance at which the book is usually held in reading, and it is also true that in hypermetropia complicated with strabismus, in which condition the crossed eye takes no part in the visual act, reading is not ordinarily attended with especial difficulty, at least during childhood and youth. The principal determining cause of asthenopia is, in fact, to be sought in the close correlation of the two functions, accommodation and convergence, whereby any given exercise of the accommodation tends to evoke a corresponding exercise of the convergence, and, conversely, any given exercise of the convergence tends to evoke a corresponding, and no greater, exercise of the accommodation. Hence, in hypermetropia, either the accommodation required for distinct vision at any given short distance may be associated with excessive convergence, and so may lead to the development of convergent strabismus, or the convergence necessary for binocular vision at the given distance may be associated with insufficient or strained accommodation for that distance, and so may give rise to asthenopia.

Asthenopia may be defined, then, as fatigue incident to a conflict between accommodation and convergence when partially divorced through the displacement of the region of accommodation in hypermetropia.

Although, strictly speaking, asthenopia is a misnomer, for it is not a condition of weakness, nevertheless weakness (paresis) of accommodation may give rise to a train of symptoms not readily to be distinguished from true asthenopia. In paresis of accommodation following diphtheria, the simulation of asthenopia is perfect, but the history of sore throat, the accompanying affection of speech and of deglutition due to paresis of the faucial muscles, the absence of previous disturbance of the accommodation, and above all the absence of hypermetropia make the differential diagnosis easy.

Fatigue from long-continued tension of both accommodation and convergence in reading or in fine work at too short a distance, as by bad light, etc., may develop into a condition of disability in which all use of the eyes becomes wearisome or painful. Astigmatism, regular or irregular, distortion of the cornea from keratitis or corneal ulcers, dazzling of the retina by diffused light transmitted by corneal nebulæ, effusions in the field of the pupil, structural defects in the crystalline lens, etc., may thus disable the eyes for continued exertion by making it impossible to distinguish small objects except at an abnormally short distance; but these are essentially cases of imperfect vision, and the disabilities to which they give rise are not properly to be classed with asthenopia.

Astigmatism may, however, be a cause also of true asthenopia. Thus in simple hypermetropic astigmatism (Ah), or in mixed astigmatism (Amh or Ahm), if the ocular meridian of least refraction is horizontal or approximately horizontal, the hypermetropia in this meridian may give rise to a displacement of the region of accommodation just as in simple hypermetropia; and in compound hypermetropic astigmatism (H + Ah) this displacement may be equal to the sum of the displacements due to the hypermetropia (H) and to the hypermetropic astigmatism (Ah). But in astigmatism there is also impairment of the acuteness of vision, due to the asymmetrical ocular refraction, and for this reason the disability resulting from any given grade of hypermetropic astigmatism is ordinarily greater than that resulting from an equal grade of uncomplicated hypermetropia. In asthenopia complicated by hypermetropic astigmatism it is, therefore, often more important to correct the astigmatism, by means of appropriate convex cylindrical glasses, than to correct the hypermetropia, by convex spherical glasses, without regard to the astigmatism.

The name *asthenopia ex hyperopsia* was formerly used to designate a state of persistent weariness and irritability of the eyes brought on by long-continued application to fine work, especially when pursued under unfavorable physical or hygienic conditions. The frequent continuance of the disability even under prolonged rest from work, also the fact that a like train of symptoms may follow enforced disuse of the eyes as a result of injury, inflammation, etc., led similarly to the recognition of a so-called *asthenopia ex anopsia*. Many of the cases formerly included under one or the other of these two groups were, in fact, cases of true asthenopia dependent on hypermetropia or on hypermetropia with astigmatism, complicated, perhaps, by some other structural defect involving impaired acuteness of vision. In other cases, in the absence of noteworthy refractive error, the explanation of the disability must be sought in a disordered state—irritability, atony, etc., of the accommodation. Under these conditions, general hygienic measures, careful attention to any accompanying irritation of the conjunctiva, etc.; in some cases the use for a time of mydriatics, to secure complete physiological rest of the accommodation; in other cases carefully regulated and progressive use of the eyes in reading, either with or without glasses, and mild stimulation of the accommodation by the systematic use of myotics, particularly of pilocarpine in a weak solution, are often most useful.

A condition of hyperæsthesia is not infrequently developed, generally in persons of irritable temperament, which manifests itself by over-sensitiveness to light or by discomfort or pain in the eyes, headache, dizziness, nausea, or other nervous symptoms, after even moderate use of the eyes in near work. Such cases are more frequently observed in women than in men, and oftenest in women in comparatively easy circumstances, or who lead a sedentary rather than a physically active life. Such patients often suffer from impaired digestion and nutrition, constipation, menstrual derangements, etc. In general they need careful hygienic supervision, regulation of the diet, correction of constipation by daily small doses of laxatives, combined, perhaps, with belladonna or hyoscyamus, or with strychnine, iron, arsenic, etc. Refractive errors (hypermetropia, anisometropia, astigmatism, etc.), so slight as ordinarily to be negligible, may also require correction by means of very carefully adjusted glasses. The regular use of the eyes in reading should be encouraged, at first for perhaps only a few minutes at a time, increasing by very gradual additions as the patient acquires confidence and the eyes gain in capacity for exertion.* Pilocarpine, instilled daily into the eyes in very small doses, is also often of decided benefit.

Disease of the frontal sinuses or of the ethmoidal cells may be a cause of persistent headache, with inability to use the eyes in near work. Sensitiveness to pressure made against the roof and inner side of the orbit, especially in the region of the pulley of the superior oblique muscle, has been noted by Ewing as a diagnostic sign of this condition (Transactions of the American Ophthalmological Society, 1900).

* E. Dyer: Trans. Am. Ophthal. Society, 1865.

A special type of ocular hyperæsthesia has been described by Förster, and named by him *kopiopia** *hysterica*. This affection stands in close relation to parametritis, and is generally rebellious to all therapeutic measures directed to the eyes; its course is extremely tedious, but recovery generally takes place when the pelvic disease has been arrested or has run its course.

Muscular Asthenopia.—As in hypermetropia, with accurate convergence, the accommodation is forced to perform its work at a disadvantage, so in myopia the relaxation of the accommodation in near vision may give rise to conditions unfavorable to the perfect and easy exercise of the convergence. As a consequence of the close physiological connection between the two adjustments, the voluntary effort to accommodate tends to evoke a corresponding degree of convergence, and the effort to converge tends to evoke a corresponding degree of accommodation. In hypermetropia, as has been already stated, either the convergence may be accurately adjusted for single vision with the two eyes, in which case the relative accommodation may be insufficient for continuous distinct vision at the distance of the point of intersection of the visual axes, or the accommodation may be exerted to the degree necessary to admit of distinct vision, and the correlated excessive impulse to converge may lead to crossing of the eyes. So in myopia, normal convergence may be associated with useless or harmful tension of the accommodation, or the relaxation of the accommodation in near vision may be associated with insufficient tension of the recti interni muscles, thus necessitating a special voluntary effort to maintain single vision with the two eyes and so leading to muscular fatigue, or, in default of this special exertion, permitting one of the eyes to diverge (relatively or actually), with sacrifice of binocular vision.

Fatigue of the recti interni muscles is mentioned by Scarpa (1801) as an occasional cause of asthenopic symptoms, and it was at one time the fashion to invoke disordered action of the external muscles of the eyeball as the principal cause, and to extol the division of one or another of these muscles as the principal remedy in asthenopia generally. But the recognition of muscular asthenopia, as a distinct type, became possible only after correct views had come to be held regarding the nature and mechanism of accommodation; and its connection with myopia was revealed only in connection with the exhaustive study, by Donders, of the accommodation in its relation to the errors of refraction.

Muscular asthenopia is a direct result of the persistence of the physiological connection between accommodation and convergence, notwithstanding the displacement of the farthest point of distinct vision (r) in the myopic eye. If, for example, we assume a myopia of four dioptries, the far point will be only one-fourth of a metre (about ten English inches) from the eye, and this will be the greatest distance at which fine print can be distinctly seen under full relaxation of the accommodation. But full relaxation of the accommodation is, under normal conditions, associated with full relaxation of the convergence, whereas the requirements of single vision demand a convergence of four *metre angles*.† The relation normally existing between accommodation and convergence must therefore needs be materially altered in order to admit of distinct binocular vision at or near the far point; and such altered relation is, in fact, observed in the greater number of cases. But myopia is, as a rule, an acquired affection, and is often of rapid development, in which case the necessary adaptation may fail to keep pace with the change of place of the far point, and thus a state of conflict between accommodation and convergence may arise. In this conflict the convergence is oftenest the victor, for the reason that double vision, when first developed, gives rise to very great confusion of sight, while excessive accommodation may, in a young person, involve no particular inconvenience other than the necessity of holding the book or work nearer to the eyes. In other cases, however, the habit is formed of relaxing the accommodation in order to see distinctly at or near the far point, and a special effort of the will may then be required to effect the necessary convergence. The fatigue which attends this effort to maintain the convergence, simultaneously with relaxation of the accommodation, constitutes muscular asthenopia.*

Regarding the curability of asthenopia opposite views have prevailed at different times. Until the dependence of accommodative asthenopia upon hypermetropia had been demonstrated by Donders, it was generally believed to be curable, at least in certain cases, and the means adopted were such as we now recognize as tending to bring about a state of improved co-ordination between accommodation and convergence, namely, the use of convex glasses of the least power compatible with the comfortable use of the eyes, which glasses were afterward to be exchanged for progressively weaker glasses, in the hope of being able ultimately to dispense with them altogether. That this plan of treatment was not altogether irrational is evident from the experience of the very large number of young hypermetropes who are able to use their eyes freely in prolonged near work, a fact entirely in accordance with the observation of Donders, that, with parallel visual axes and also under moderate convergence, the hypermetropic eye ordinarily brings into use much more of its accommodation than does the emmetropic eye under like conditions. Moreover, it is not uncommon for asthenopic symptoms, occurring in connection with hypermetropia of moderate grade, to disappear after a few weeks or months of relief from strain afforded by the use of weak convex glasses in reading and study. In these cases the glasses give great relief when first worn, but after a time the need of them comes to be less urgently felt, so that the child begins to do without them, and at last forgets to use them at all. But these cures, however satisfactory they may be for the time being, are apt to be followed by relapses, which, again, may yield to a new course of treatment by glasses, until, with increasing age and the accompanying restriction of the range of accommodation, the habitual use of convex glasses becomes imperative.

Asthenopia may be treated also by acting directly upon the accommodation by the methodical use of myotics. In his original study of the action of Calabar bean, Donders observed that the range of accommodation is positively increased after the instillation of this drug, and that this increase, which is greatest after about two hours, diminishes rather slowly. He observed, also, a material increase in the accommodation as related to the conver-

* From κοπιάω, to become weary, and ὤψ, eye.

† *Metre angle*, a name proposed by Nagel to designate the unit of convergence corresponding to one dioptrie of accommodation. In convergence for a point 3, 2, 1, ½, ⅓, ¼, etc., metres distant, the convergence is said to be of ⅓, ½, 1, 2, 3, 4, etc., metre angles, and the accommodation (in emmetropia) is similarly of ⅓, ½, 1, 2, 3, 4, etc., dioptries.

* The conditions which determine the development of asthenopia may be stated in a general form as follows:

In the normal condition of the eyes (emmetropia), under an exercise of the accommodation equal to n dioptries, each eye is adjusted for distinct vision at a distance of $\frac{1}{n}$ metre, and with this accommodation of n dioptries there is associated a degree of convergence equal to n metre angles; the visual axes intersect, therefore, at the exact distance ($\frac{1}{n}$ metre) for which the two eyes are severally accommodated, and the two adjustments are performed in perfect harmony.

In hypermetropia a given exercise of the accommodation, say of h dioptries, is required for distinct vision at a distance, at the same time that the convergence is relaxed to zero (parallelism of the visual axes), so that for vision at the distance of $\frac{1}{n}$ metre a degree of convergence equal to n metre angles must be associated with an exercise of the accommodation equal to $n + h$ dioptries; the relatively excessive demand thus made upon the accommodation may be attended with fatigue from relative insufficiency of the accommodation (*accommodative asthenopia*).

In myopia, say of m dioptries, distinct vision at a distance is impossible, and for vision at a distance (within the limits of the region of accommodation) of $\frac{1}{n}$ metre from the eye, an exercise of the accommodation equal to $n - m$ dioptries must be associated with a convergence of n metre angles; the relatively excessive demand thus made upon the convergence may be attended with fatigue from relative insufficiency of the recti interni muscles (*muscular asthenopia*).

gence, amounting to rather more than 0.8 dioptric eleven hours after the instillation; and he makes the very significant remark that "hypermetropes, under the double advantage of smaller circles of diffusion and of easier tension of accommodation, lose for a time their asthenopia." The introduction of pilocarpine in ophthalmic therapeutics has made it practicable to keep up a moderate myotic action for an almost indefinite period, without injurious spasm of accommodation. In cases of asthenopia in young persons, associated with hypermetropia of low grade, pilocarpine may be employed in the form of a weak solution, instilling any desired fraction of a minim, measured by means of a slender glass pipette. The instillation may be made morning and evening, and after a few weeks at night only; or the effect may be gradually diminished by reducing the quantity used or the strength of the solution. In this way it is often practicable to tide over an attack of asthenopia in a young person without interrupting school work, and so to postpone the use of glasses for perhaps many years.

In asthenopia dependent on hypermetropia of high grade, the only effective resource is in the use of convex glasses, and these should be of a strength sufficient to correct fully the refractive error. Owing to the fact that a part of the hypermetropia is almost always latent (see *Hypermetropia*), fully correcting (neutralizing) glasses often prove less acceptable in the beginning than those of less power, but in every case the selection of glasses should be made with distinct reference to the total hypermetropia, and in the expectation of ultimately applying the full correction. In a few cases of asthenopia any exercise of the accommodation even with convex glasses is attended with pain, so that it may be found necessary to have recourse to atropine for the purpose of maintaining for a time a state of complete physiological rest. During the maintenance of the mydriasis reading may be permitted with the aid of stronger convex glasses which must be exchanged for neutralizing glasses when the accommodation is allowed to resume its function. The hypermetrope who requires convex glasses for reading sees perfectly at a distance with the same glasses, and, as a rule, finds it more convenient and comfortable to wear them constantly; but in this he may generally be permitted to follow his own pleasure. If for any reason he is disinclined to wear glasses constantly, a compromise may often be effected by prescribing spectacles for continuous reading and an eyeglass (*pince-nez*) for occasional use.

In muscular asthenopia the treatment consists primarily in the correction of the myopia, together with any astigmatism that may be present, by means of neutralizing concave spherical or spherico-cylindrical glasses. The glasses should, as a rule, be mounted in a spectacle frame rather than as a *pince-nez*, and they should be worn continuously. The relief afforded by neutralizing glasses is generally immediate and complete, but in a few cases it may be necessary to prescribe stronger concave glasses, which shall over-correct the myopia and so compel some exercise of the accommodation in distant vision and a correspondingly increased exercise of the accommodation in near work. This over-correction, which may be carried as high as three dioptries in children or in young adults with ample range of accommodation, is free from the dangers and disabilities which attend the wearing of too strong concave glasses in uncomplicated myopia.

The decentration of concave glasses outwards, or, what amounts to the same thing, the grinding of the necessary concave spherical or spherical and cylindrical surfaces on prisms of from 1° to 8° angle, set with bases of the prisms toward the nose, is occasionally of advantage by correcting the refractive error and at the same time giving some measure of direct relief to the recti interni muscles. In the higher grades of relative muscular insufficiency, division of the tendon of the rectus externus muscle in one eye or in both eyes may be indicated, but operative interference should be considered only after an exhaustive investigation of each particular case, and generally after a full trial of less radical methods.*

In the treatment of asthenopia, whether accommodative or muscular, the chief reliance is to be placed upon the correction of the underlying error of refraction (hypermetropia, myopia, astigmatism, anisometropia) by means of appropriate glasses (convex, concave, cylindrical, or of different power for the two eyes). A practically normal relation of accommodation to convergence is thus established, and, apart from subsequent structural changes in the eyes, the glasses which perfectly correct the refractive error in youth suffice until, with advancing age, the sight begins to be presbyopic (see *Accommodation and Refraction*, *Astigmatism*, *Hypermetropia*, *Myopia*, *Presbyopia*, *Spectacles*). *John Green.*

ASTHMA.—SYMPTOMATOLOGY. — Asthma is a disease characterized by attacks of true intermittent, but severe, dyspnœa, accompanied by general sibilant râles. In a typical case of the complaint the patient may retire to bed in apparently good health, and with no more warning of the impending attack than in a case of nocturnal epilepsy; but after a few hours' sleep his respiration becomes labored and whistling, so that it even may be heard by others while he is still asleep. Soon he is himself awakened by his difficulty of breathing, though if accustomed to such visitations he may endeavor to continue his slumber, and for a while succeed in doing so. Ere long, however, not only sleep, but all rest becomes impossible by the supervention of a most urgent dyspnœa, whose symptoms would indicate great peril to life in any other disease. In asthma, however, though the distress be great, alarm is significantly absent from the patient.

Careful observation now will show that the difficulty in the breathing is mainly due to some interference with the *expiration*. Unlike croup, asthma allows the air to readily enter with the inspiration, but the expiration appears as a laborious struggle which succeeds in forcing the air out only with painful slowness, rendering this process from two to four times the length of the inspiration. This disproportionate expiration is characteristic, for though the expiration is prolonged in emphysema and phthisis, yet it never equals the delay of asthma. The patients, therefore, dread the most ordinary acts which entail a prolongation of the expiration, like coughing, or even speaking, but especially laughing, for in some this is itself sufficient to induce an attack, while on the other hand a forced inspiration will often serve to break up the paroxysm.

Owing to this impeded exit the residual air increases in the lungs to such an extent that the intercostal spaces become much widened and the girth of the chest so expanded that the ordinarily worn clothes of the patient will not come together by from one to three inches. The upper abdomen also becomes similarly distended by the forced descent of the diaphragm pushing down the liver, stomach, and spleen. The walls of the chest finally seem too fixed to allow of any but the slightest expansion and retraction in breathing, and this condition gives to the patient a sense of suffocative tightness, as if caused by some external compression. Salter notes also, as a frequent symptom, a persistent itching of the chin, and often between the shoulder blades and sternum as well, supervening with the first symptoms of asthmatic breath-

* The indiscriminate cutting of the recti and even of the oblique muscles, in the hope of thereby curing asthenopia, which was at one time somewhat extensively practised, has been justly referred to by Donders as "a melancholy page in the history of operative ophthalmic surgery." Exaggerated or perverted ideas regarding disturbed balance of the ocular muscles, as the determining cause not only of different conditions of disability more or less closely simulating asthenopia, but also of all sorts of nervous manifestations occurring in other and even remote parts of the body, have borne fruit, in recent times, in reports of numerous and oft-repeated operations on one and the same muscle or on different muscles, for which it is difficult to find justification in the known facts of physiology or pathology. Operations on the ocular muscles have a legitimate place in the treatment of muscular asthenopia, as truly as in strabismus; in both conditions grave and often irreparable harm may result from a hasty or ill-considered resort to operative procedures.

ing and passing off with the full development of the paroxysm.

DIAGNOSIS.—Physical exploration of the chest now affords a group of characteristic symptoms which render the diagnosis of asthma a matter of no great difficulty. The lung distention exaggerates the pulmonary resonance on percussion and extends its area in every direction, behind the clavicles, over the heart, and downward over the regions of normal splenic and hepatic dulness. From the same cause the vocal fremitus either disappears or is much diminished in those localities where it is well marked in health. Auscultation, however, is the most decisive in its indications, for the normal vesicular murmur is quite displaced by high-pitched sibilant râles, which often attract the attention of bystanders, as they become audible to some distance from the patient. On applying the ear to the chest, however, one distinguishes very fine râles, mingled with others larger and graver in tone, which, moreover, seem to shift in location as if sometimes near to the ear, and then farther off, like a wavy passage of air over various musical tubes In simple asthma these râles are purely sibilant, but in prolonged attacks, or when bronchitis is also present, they become more or less crackling.

As the disordered respiration continues, the sufferings of the patient for breath become extreme. His whole frame partakes in the struggle for air, which leads him involuntarily to try to expand the chest yet more and more. He strives to make immovable his back, shoulders, and head, so that from them the accessory muscles of respiration may pull upon the already tense walls of the thorax. Hence he fixes his arms or plants his elbows on a table or other support, while his head is thrown back, his mouth panting, his eyes widely opened and fixed, and his face pale and bedewed with perspiration. He speaks only in monosyllables, and resents everything which calls him off, even for a moment, from his efforts to breathe. The pulse grows small and feeble, and the patient becomes so cyanotic and cold that his wet, clammy skin and ghastly expression are apt to inspire strangers with fear of his near dissolution.

The duration of an attack varies greatly, not only in different patients, but in the same patient at different times. The attack may come on in the night and pass off soon after daylight, or it may be prolonged into a series of exacerbations and incomplete remissions for several successive days and nights, until the sufferer becomes almost fatally exhausted. In like manner the subsidence bears little relation to the severity or duration of the attack. Either as the effect of remedies or spontaneously, the breathing may become suddenly easier, the rigidity of the chest walls pass off, the inspirations grow fuller and the expirations shorter, and the patient, who but a few moments before seemed about to perish in his distress, will soon return, after a moderate expectoration of a clear frothy mucus, to regular and natural breathing, with no other indication of his recent sufferings than an expression of fatigue. At other times, especially if bronchitis supervenes, the attack passes off in a series of irregular paroxysms of difficult breathing, alternating with coughing and free expectoration. In many fully developed attacks, however, the patient has carefully to watch for its decline by avoiding all causes of exacerbation or relapse, especially from eating, so that some asthmatics are obliged to go to bed fasting if they are to pass that night free from dyspnœa.

ETIOLOGY.—In asthma, as in other markedly spasmodic diseases, the afferent impression which induces the attacks varies indefinitely, both in kind and in seat. The sensory nerves, however, which are distributed to the mucous membrane of the respiratory tract, including the olfactories, afford the most frequent instances of the curious impressibility which excites reflexly the asthmatic spasm. On this account bronchitis itself takes the lead, for asthmatic breathing occurs in so large a proportion of both acute and chronic forms of this affection that some writers have gone the length of ascribing all asthmas to bronchitis. It is easy to show, however, that asthma lacks no element of a true neurosis, and that in many typical cases there is no bronchitis whatever. Yet, so great is the proclivity to it in bronchitis, that even comparatively transient affections, like measles and pertussis, sometimes entail a lifelong asthma as a sequel to the bronchial irritation attendant upon their course. In the initial or "dry" stage of acute bronchitis, along with the sense of soreness and tightness across the chest, auscultation reveals the presence of true asthmatic wheezing, while in chronic bronchitis asthmatic attacks often occur upon very slight provocations, such as by rising too suddenly, or from attempting too long a sentence in talking.

After the irritation of bronchitis, the list of excitants of asthma which take their start from the sensory nerves of the respiratory mucous membrane varies in a most extraordinary degree. Nearly every asthmatic has his specialty of the kind, so to speak, often with a most unaccountable caprice of choice. The writer has known of a gentleman who, while in his room on an upper floor, yet could tell at once by his breathing that buckwheat flour had just been brought into the house. The proximity of certain animals, especially cats, will induce an attack with many asthmatics, who may suffer from this cause for a long time without being aware of its origin until they accidentally discover that the tightness comes on so soon as they come near a horse or a dog, or pay a visit to a menagerie. The proclivity to asthma from deranged innervation within the nasal cavity is also illustrated by numerous histories of cures by the removal of polypi or other causes of nasal obstruction or irritation. The smell of powdered ipecacuanha is often mentioned as a similar excitant, but although this may be ascribed to irritation by minute particles of ipecac inhaled—and the like may be said of asthma from the inhalation of mustard or of the fumes of a sulphur match—yet such an explanation cannot hold good in asthma caused by the smell of violets or of other fragrant flowers. In fact nothing can be more whimsical than the behavior of asthma as regards either what may be resented as an ingredient of the air inspired, or simply from the general character of the outer atmosphere. One asthmatic may find comfort in the air of a particular locality which another asthmatic can enter only at his peril. Salter mentions the instance of two friends who could not exchange visits at their country houses, which were on opposite sides of a ridge, though both were suited with the air of London. The air of large cities, in fact, despite its smoke and dust, agrees oftener with asthmatics than does the pure air of the country.

Next to the respiratory tract, the most frequent excitants of asthmatic attacks proceed from the alimentary canal, especially from its gastro-duodenal portion. Most asthmatics, indeed, are also dyspeptics, and are thus doubly obliged to be particular in their dietary. The list of forbidden articles is singularly varied, as we might expect from the range in this respect among dyspeptics as a class. Some will have asthma if they take cheese, others almonds, others apples or wine or tea or tobacco, etc.; the peculiarity being that the particular idiosyncrasy is generally consistently adhered to, perhaps for many years, or at least as long as natural tastes or likings are apt to last. With many patients, however, it is not so much a particular article which brings on a paroxysm, but a too hearty meal for them of any kind. On the other hand, constipation is the sure provocative with some who are also often promptly relieved by a cathartic. In women, uterine derangements have their share in the causation of asthma, though not as frequently as they serve to excite other spasmodic diseases; while a certain proportion remains whose attacks seem to be induced solely by mental excitement, particularly of a depressing kind.

Among the special predisposing causes of asthmatic seizures is the state of sleep, for the majority of distinct attacks set in after the patient has been asleep for some time, and oftenest during the hours of profound slumber, after midnight. Some asthmatics are obliged to keep awake after noting certain of their usual premonitory

signs, or the attack will surely develop if they happen to sleep at all. The relation of sleep to the attacks is also well illustrated in peptic asthma, for though the offending article of diet be taken in the morning, yet it will not be until its customary hour in the night that the asthma which it induces will come on. This chronometry of asthma exemplifies the real but unperceived continuousness of the spasmodic nervous diseases, in all of which the outbreaks are sudden only in the manifestation of certain symptoms, and which mere symptoms, like spasm, etc., are therefore too often mistaken for the whole disease. The reasons which have been adduced by various writers for this nocturnal feature of asthma, as in the analogous instance of nocturnal epilepsy, are too hypothetical to call for extended discussion. It is interesting, however, to note that the mere fact of darkness seems to dispose to the attacks. Not a few patients can prevent them by keeping a light burning brightly in their rooms, while if the light be put out they will soon wake up with difficult breathing.

Asthmatic dyspnœa is also occasionally secondary to other diseases or morbid states, in which case it ranks only as a symptom of them. Thus, in heart disease, particularly in mitral stenosis, the widespread congestion of the bronchial mucous membrane may excite real asthmatic symptoms, which, moreover, should not be confounded with true cardiac dyspnœa. In the latter, the patient resembles one who is out of breath from muscular exercise, as after running, but cardiac asthma, properly speaking, shows the same derangement of expiration as ordinary asthma, and is evidently due to the bronchial hyperæmia acting as a reflex excitant. Toxæmia also sometimes produces asthmatic attacks, especially in gout and in uræmia. In the gouty cases the attacks are sudden, nocturnal, and quickly accompanied by a great bronchial flux, which may be pinkish from capillary hemorrhage. A patient of mine once expectorated two large basinfuls of such mucus between midnight and morning, but after three such attacks they ceased and never recurred afterward. In gouty asthma alarm is wholly absent, but not so in uræmic asthma. Here again, as in the cardiac cases, the dyspnœa should not be mistaken for asthma, if it be due, as it commonly is, to pulmonary œdema or to pleuritic effusion. True uræmic asthma is characterized by sudden attacks of difficult breathing with great terror, and often also with severe palpitation of the heart, which is usually much hypertrophied from the arterial obstruction of chronic renal disease. After a few attacks, if not after the first one, the breathing remains permanently shortened, and the patient dreads the slightest cause of cardiac excitement. In most cases uræmic asthma is a late, and not a favorable symptom of chronic Bright's disease, particularly of the granular variety, and it is commonly associated with abundant light-colored urine of low specific gravity, with or without albumin, and with evidence of general endarteritis as illustrated by the tortuous and rigid temporal and radial arteries. In one case, however, seen by me in consultation, the kidney affection seemed to follow the asthma rather than to precede it. The patient, a gentleman about fifty years of age, was suddenly seized, while apparently in perfect health, with extreme dyspnœa His physician on arrival tested his urine and found it heavily loaded with albumin. This albumin, however, wholly disappeared in a few days, until after a fortnight, when he had another exactly similar seizure, also in the daytime. The interesting circumstance connected with the second seizure was that he had sent a specimen of urine, passed only an hour before the attack, to be examined, and it was found to be wholly free from albumin and of normal specific gravity; but some tested immediately after the seizure set in became nearly solid on boiling. This observation of the reappearance of albumin only at the attacks, with its gradual but ultimately final disappearance until another fit of dyspnœa arrived, was repeated a number of times, once by myself, as daily examinations of his water were kept up. He finally succumbed, some months later, to extensive effusions in both pleuræ.

Asthmatic attacks are also sometimes plainly associated with the disappearance of chronic skin eruptions. A patient of mine always became asthmatic whenever an old eczema of the chest began to subside, until he found that he could rid himself of the infliction by an artificially induced eczema with croton oil.

AGE.—Asthma may begin at any age. An intelligent patient of mine, seventy years old, stated that the disease was observed in him on the first day of his life. There is, however, a special proclivity to it in the first decennial, owing to the predisposition of children to bronchitis. Of 225 cases, Salter had 71 under ten, and in 11 of them it began in the first year. The prognosis of asthma is better in childhood than later on, as it is frequently outgrown after puberty, particularly if the causes of bronchitis be carefully avoided. The cases which begin in adolescence are relatively few, and are then generally of the purely spasmodic form. But in middle life the proclivity to asthma again increases with the greater exposure from outdoor occupations, but, unlike bronchitis, asthma as a new disease begins to fall off, and progressively decreases in its ratio till seventy. The common impression that asthma is a disease of old age is a mistake, arising rather naturally from the frequency of chronic bronchitis with asthmatic wheezing among elderly persons.

SEX.—The influence of sex is considerable, the preponderance of males being about double that of females. That this, however, is due to the greater exposure of men to causes of bronchitis, is shown by the fact that the cases of the pure spasmodic variety are about equally divided between the sexes.

HEREDITY.—Asthma belongs also to the markedly hereditary diseases, as might be expected from the characters of its common accompaniments. An inherited proclivity to bronchitis is observable as often as a family tendency to phthisis, while neuroses, on the other hand, are more frequently of constitutional origin than any other class of affections. About thirty-five per cent. of all asthmatics, therefore, will show some sign of heredity, and oftener from the paternal than from the maternal side—a fact, moreover, in keeping with the greater frequency of the disease among men.

PATHOLOGY.—Asthma has no characteristic anatomical lesions. That extensive pathological alterations are often found post mortem is quite true, but in most cases they are caused by intercurrent affections, particularly by bronchitis. Under this head come hypertrophy of the circular muscular fibres, with consequent narrowing of the bronchioles, it may be even to occlusion, collapse of lobules, emphysema, and dilatation of the right side of the heart, with the various sequelæ of these conditions, to be detailed in their proper place (see *Bronchitis*). But there are some organic alterations which may be ascribed to the labored respiration of asthma alone, when severe and prolonged attacks come so often that the parts have no opportunity to return to their normal state during the intervals. That this is the occasion of such changes appears from their complete absence in those patients who have perfect intermissions between the attacks. The first of these effects is dilatation of the right heart, caused by long labor in the difficult propulsion of blood through the lungs so soon as apnœa occurs in any form. During a paroxysm of asthma, the left heart and the systemic arteries are relatively empty and the pulse is small, while the systemic venous system from the right auricle backward is everywhere overloaded. The heart beat is then found, not under the nipple, but in the scrobiculus cordis; partly, it is true, from the displacement caused by the dilated left lung, but equally also from the distention of the right ventricle. Another constant result is emphysema, or permanent overdistention of the air vesicles, caused by the progressive accumulation of the residual air from the imperfect expiration. Emphysema may thus be found in old asthmatics, whether they have had chronic bronchitis or not. Lastly, from the combined derangement of the pulmonary circulation caused by the intermittent apnœa and the permanent emphysema, we have a tendency to bronchial flux to relieve the congested

vessels, which finally adds chronic inflammation to chronic hyperæmia, and thus establishes the vicious circle of impeded circulation causing bronchitis, and bronchitis in turn causing progressive circulatory impediment.

These slowly induced effects finally produce those changes of personal appearance which mark old asthmatics. As the general nutrition suffers from the persistent congestion of the liver caused by the impeded outflow of the right heart, these patients are usually thin, pale, or cyanotic, and with deficient muscular power. The eyes are prominent and watery, the voice is weak, the gait slow and measured, and the back rounded, often to great deformity. The head, however, is always thrown back between the elevated shoulders, and the trunk of the body is kept so rigid that the arms hang passively, swung by the movements of walking.

Leyden endeavored to demonstrate that the cause of asthma lies in the presence of sharply tipped octahedral crystals, found abundantly in the expectoration which terminates a paroxysm of asthma, and which, he supposed, by their numerous fine points set up a reflex irritation of the terminal branches of the vagus in the bronchial mucous membrane. This theory, however, is sufficiently negatived by the discovery of the same crystals in the secretions of other bronchial affections in which there is no asthma. That asthma, instead, is essentially a functional neurosis is readily apparent when the disease is studied in uncomplicated cases, for in them, though there be neither bronchitis, heart disease, nor toxæmia, we have typical attacks developing in association with phenomena which belong to nervous diseases alone. Of such phenomena we would cite: 1. Extreme suddenness of onset, as the immediate asthma caused in some by certain odors. No less sudden also in many cases is its departure, as upon the inhalation of certain fumes. This feature militates also against the theory of Weber, who ascribes asthma to turgescence of the mucous membrane, narrowing the calibre of the bronchi as an acute coryza impedes breathing through the nose. Störck lent support to this view by laryngoscopic observation of tumefaction of the tracheal mucous membrane as far as the right bronchus in an asthmatic during an attack. Bristowe, moreover, cites the rapid subsidence of cutaneous turgescence in some cases of urticaria evanida as affording some support to congestive swelling of the bronchial mucous membrane being a factor in the etiology of asthma. But though it be freely granted that the agonizing struggles of an asthmatic for air may have considerable effect upon the circulation of the bronchial walls, yet the fact remains that no known swelling, however evanescent, vanishes so quickly as some true asthmatic dyspnœas vanish, the patients becoming natural often more speedily than is common after either epileptic or neuralgic attacks. 2. Like other spasmodic neuroses, whether sensory or motor, asthma often has characteristic prodromes of the attacks. One of the most common is a feeling of almost irresistible drowsiness, giving way to which, the patient well knows, will be followed by the old dread awakening. With some, on the other hand, unusual wakefulness is a sure precursor. As in epilepsy and in migraine some are warned by the temper becoming very irritable, or the spirits causelessly depressed, while others experience unwonted buoyancy of spirits. Moreover, as in these neuroses, the attacks are sometimes preceded, but oftener followed, by an abundant flow of pale, limpid urine. 3. Mental influences alone are known both to excite and to suspend the attacks with some. In certain patients a fit of anger may induce an attack immediately, in others, more significantly still, it invariably insures the attack during the succeeding night, long after the angry emotion is gone or forgotten. 4. It is only in functional neuroses that we find many and widely differing exciting causes. Thus epilepsy has been wholly relieved by the expulsion of a tapeworm, or of a renal calculus, or by trepanning. But in this respect asthma surpasses all other complaints, and the bearing of this fact upon the nervous character of the disease appears when contrasted with bronchitis, which involves, moreover, just the same parts which asthma affects. Bronchitis certainly, as well as any other disease with palpable lesions, cannot be excited by such a motley array of influences as the smell of cats or of violets, the eating of raisins or nuts, by constipation, by depressing emotions, or by the extinguishment of a light. 5. A decisive consideration is to be noted also in the intermediate condition between the paroxysms. In typical asthmatics in whom no organic changes have yet been induced, such as emphysema or the effects of chronic bronchitis, the existence of asthma cannot be even guessed. The patient shows to inspection and to physical exploration of the chest no more signs of being subject to violent and prolonged attacks of dyspnœa than an epileptic's muscles tell of his convulsions.

Mechanism.—Asthma, therefore, may be regarded as essentially a derangement of the innervation of the respiratory apparatus, disturbing the rhythmical succession of contraction and relaxation by a muscular cramp, which interferes chiefly with the act of expiration. But the mechanism, so to speak, of the asthmatic paroxysm itself is by no means agreed upon. The majority of authorities ascribe it to narrowing of the bronchioles by spasm of their muscular coat, while others maintain that it consists in spasm of the diaphragm and costal muscles. Each of these theories may be said to explain what the other leaves unexplained, and hence it is doubtful if either of them alone can be regarded as adequate. The arguments in favor of the latter theory are:

1. During the attacks the whole aspect of the patient is that of extreme external muscular rigidity. Both the thorax and abdomen appear fixed and immovable, and show none of those strong heaving and expansive efforts which are visible in other forms of dyspnœa. Thus, in asthma, the diaphragm remains depressed, as if arrested in inspiration, and the muscles of the distended abdomen grow hard and tense as they labor in vain to overcome the resisting diaphragm and thus assist expiration. From the powerful contraction of the abdominal muscles it even happens that the lower ribs often bulge during the effort at expiration. On the other hand, when there is obstruction in the respiratory tract, as in laryngeal croup, œdema glottidis, etc., the phenomena are all different. The difficulty is then plainly in the inspiration, and not in the expiration, and the ribs to which the diaphragm is attached actually sink in, even during inspiration. Why obstruction in the bronchi should reverse all these effects is not explained.

2. The theory of bronchial spasm fails to account for the difficulty of expiration in asthma. If contraction occurs in the tubes, it must interfere with both inspiration and expiration equally, unless it can be shown that the circular fibres have a valvular action at the points of contraction, admitting the incoming, but interfering with the outgoing, current. This phenomenon, however, has never been induced in animals experimentally, and is even difficult to imagine. Moreover, that nothing of the kind occurs is proved by auscultation, for a valvular obstruction to the expiration would totally alter both the quality and the pitch of the expiratory sibilus, which is not the case.

3. On the other hand, the theory of diaphragmatic spasm explains why inspiration is easier than expiration in asthma, because it is well known that partially cramped voluntary muscles, like the diaphragm, can always be stimulated to further contraction, though still disinclined to yield to relaxation. This appears strikingly in tetanus, in which disease the tonic rigidity of the muscles never wholly gives way, although every few moments fresh and powerful contractions occur in response to the slightest external impressions. Meantime, the statement that the depressed state of the diaphragm is a passive condition due to the overdistention of the lungs with residual air, is negatived by the active muscular contraction of the abdomen above referred to, which is quite different from the passive distention of the abdominal walls when the diaphragm is depressed in emphysema.

4. The asthmatic paroxysm is always aggravated by certain movements which confessedly occur only in the

diaphragm itself. Patients, on this account, especially dread to laugh or to do anything which slows or checks the relaxation of the diaphragm, such as long talking. But how these actions could in any way affect bronchial constriction is difficult to conceive.

On the other hand, there is one incontestable proof that constriction of the bronchi does take place in every case of real asthma, and that is the invariable presence of general sibilant râles of every variety of size, from fine whistling to large cooing sounds. In true asthma these sounds are purely tubular, and from their shifting character, above alluded to, it is plain that they are produced by progressive waves of contraction in the bronchial walls, and not by a uniform diminution of their calibre, such as general tumefaction (Weber) would occasion. These râles, moreover, are simultaneous with the onset of the attack, as they are audible sometimes in the breathing of an asthmatic, even before he is awakened by a fit, and so constant are they that no dyspnœa can be termed asthmatic if there be no wheezing. Now, the theory of diaphragm spasm wholly fails to account for these characteristic bronchial râles. If we had diaphragm spasm alone, the symptoms then would rather resemble *burking*, or, more properly, the dyspnœa which is often the fatal complication of tetanus, in which disease death results from tonic spasm of the respiratory muscles. Here, as I have had personal occasion to note, there is no wheezing whatever.

From these considerations the view of Lebert seems to us preferable, namely, that the asthmatic paroxysm begins with spasm of the bronchial muscles, much as the first discharge of epilepsy often begins with a special group of muscles, and then spreads to other and wider muscular associations. Considering how intimately and constantly the muscular actions of respiration are associated, it is easy to conceive how disordered innervation of the bronchial muscles may become quickly accompanied by disordered innervation of the diaphragm, and thus check the return of inspired air. Some ten such respirations would suffice to inflate the lungs to the extremest degree observable in asthma, until the whole muscular apparatus of expiration would join in the spasm and complete the picture of this dyspnœa, in which condition almost the only movements which remain in the distressful breathing are the lifting actions of the neck and shoulder muscles. Lebert justly insists on the contrast between the pulmonary dilatation in asthma and its absence in fibrinous bronchitis, in which disease, though the obstruction is great and the constriction of the bronchioles a tubular narrowing, yet there is but slight, if any, dilatation; which proves, therefore, that something more than bronchial constriction is needed to explain all the clinical features of asthma.

TREATMENT.—Much the greater number of reputed remedies for asthma are little else than palliative, because their operation merely relieves a paroxysm or attack of the complaint, just as opium may relieve the pain of a syphilitic node without producing the least effect on the cause of the symptom itself. The peculiar motor spasm of asthma is not the disease, but only a symptom of it, the same in nature with pain, and hence, like other mere symptoms in nervous diseases, it can be affected by a great variety of influences. Thus, such unlike agents as caffeine, chloral, ether, and tobacco, or the inhalation of stramonium or of nitre fumes, are each spoken of as marvellously relieving certain confirmed asthmatics. No sooner does the patient begin to experience the special effects which these drugs produce in a healthy man than the agony of his breathing subsides, and a restful calm succeeds as by magic. But the great disappointment with these seemingly effective remedies is that the longest use of them brings the patient no nearer getting rid of his enemy than when he began. He may break up his attacks for years with his special prescription, but the asthmatic fit is as ready to return, and as severely, as if no remedy for it ever had been tried.

The reason for this failure is fundamental. These so-called remedies for asthma are all nervines, and no agent like opium, or aconite, or stramonium, or ether, whose whole medicinal action is obtained by one dose, can do anything more than that one dose does. However often repeated, no cumulative progressive effect follows upon the administration of nervines, and hence they can affect only the functional manifestations of a constitutional disease. All that such medicines can do is to produce some immediate but temporary change in some symptom of the complaint, but no more. There is hence a parallel between the curious variety of the exciting causes of asthma in different persons and the like variety both in the nervines themselves and in their disproportionate efficacy in different patients. For while the exciting causes show by their incongruity that they are not true but only accidental elements in the case, so the diverse nervines recommended for asthma show that they affect only some accessory but not essential factor in the disease. When a nasal polypus makes one patient an asthmatic and a loaded rectum another, neither of these cases throws the least light on the true cause of asthma. Likewise when a nauseant emetic and a glass of hot spirits and water are each said to "work like a charm" in some asthmatics, we can scarcely say of such remedies that they bring us nearer the true therapeutics of the malady, for it is plain that they modify only some chance association of perverted function.

In this class of palliative remedies we would assign the first place to the mydriatics, belladonna, hyoscyamus, stramonium, and duboisin. The wide range of disorders in which these medicines have been found beneficial is due to a general principle in their operation, which also suggests the explanation of their use in asthma—viz., that they relieve disordered innervation of involuntary muscular fibre by a motor stimulant action which restores its rhythmical contraction when it has been arrested by spasm from any cause. Spasm and paralysis are associated phenomena in unstriped muscle, tetanic contraction of one portion and relaxation of the remainder taking the place of the normal wave movement throughout the whole. Hence the use of belladonna and its allies in spasmodic action of the bladder in cystitis, in nocturnal incontinence of urine, in the constipation of women from reflex pelvic irritation, in spasmodic gastrodynia, in cardiac pains when due to left hypertrophy deranging the rhythm of the two sides of the heart, etc. As with other nervines, the earlier they are given in the attack the more pronounced and speedy is the effect. A full dose of the tincture or of the fluid extract of belladonna should be given, enough to produce well-marked constitutional effects, and then the dose should be repeated in two hours if there be only imperfect relief. If the second dose fails to affect the breathing, a very effective method is to give a hypodermic of atropine injected deeply into the nape of the neck, a locality which is the seat of a sensation of great weariness in severe attacks of asthma, and which this measure often mitigates at once, after other employment of the remedy has failed. Hyoscyamine sometimes affords more relief than atropine, but in most cases is not superior to it. Other patients are best relieved by the inhalation of the smoke of stramonium leaves, for which purpose they may be lit at the bottom of a cup, or used like tobacco in a pipe, or made into cigarettes; the effort being to inhale the fumes as deeply as possible, when the dyspnœa sometimes is found to vanish with surprising rapidity.

Coffee should be reckoned also among the nervines which are effective in asthma by a stimulant action. It should be made very strong, taken always on an empty stomach and taken hot, for the sipping of the potion is not without its own effect, as it has been shown by [illegible]necker that the act of swallowing itself powerfully stimulates the cardiac and pulmonary branches of the vagus. Coffee taken after eating aggravates asthma by interfering with digestion. In some cases I have found the alkaloid caffeine of temporary benefit, but on the whole I regard it as inferior to the freshly made and strong infusion. Hot coffee is particularly good in asthma [illegible] bronchitis, as it facilitates the expectoration while i[illegible]

lieves the spasmodic condition. It is in the same class of cases, also, that the muscle stimulant, nux vomica, is sometimes beneficial. Here again the tincture or the fluid extract of the drug is preferable to its alkaloid, strychnine.

Next in order come the nervines which probably relieve the asthmatic paroxysm by a sedative action on the initial irritant impression. Among these we would enumerate alcohol, the ethers, chloral, and opium. It should be noted that while alcohol is a stimulant to the heart and to some cerebral functions, it is an immediate sedative to the sensory nerves, and this sedation steadily increases in proportion to the dose. Sulphuric ether, when taken internally, resembles alcohol in these respects, though its sedative effects are much more pronounced. Hence the use of both alcohol and ether in the muscle cramp of intestinal colic and in spasmodic affections of ducts generally. Full doses of spirits, therefore, taken hot, will relieve some asthmatics to the exclusion of all other remedies; but the relief does not occur generally until enough is taken to intoxicate a well person, though it rarely does so with an asthmatic. Sulphuric ether, however, is much more generally effective, especially in the preparation of the Spiritus Compositus, or Hoffman's anodyne, owing to the oil of wine which it contains. As this latter ingredient is expensive, it is sometimes fraudulently omitted, with a plain falling off in remedial power over the attacks. The dose for the paroxysm should be not less than two drachms. As the latter acts in a different way from the belladonna (being more connected with the sensory element of the spasmodic condition, while the belladonna affects the motor), an unquestionable gain is secured by administering these two remedies together.

As might be expected, there is much contradictory testimony about the value of opium in asthma. This need not be wondered at in view of the widely different effects of opium, *e.g.*, as a soporific, in different individuals. The mode of administration, however, counts more with this remedy than with any other, for the speedy effect of a hypodermic of morphine is much oftener successful than morphine or opium taken by the mouth. This, however, is in accordance with the general rule that the more quickly a nervine is felt, the more effective it is against any spasmodic affection—*e.g.*, arresting an epileptic fit by a sudden irritant impression, but which it fails to do if applied gradually. Chloral in large doses, thirty to sixty grains, is claimed as an excellent remedy for asthma; but the patient's tolerance of this drug, sometimes fatal in only fifteen-grain doses, should be well established before this treatment is tried. Inhalations of nitrite of amyl often arrest a commencing attack, but are not of much use in a fully developed paroxysm. The fumes of the nitrate of potash, however, inhaled by burning cigarettes made of rice paper dipped in a saturated solution of the salt and then dried, are much more generally effective. This remedy undoubtedly acts by virtue of the well-known locally sedative properties of potash itself, and hence may well co-operate with the different action of the fumes of stramonium leaves rolled up with the nitre paper.

Lastly, we have the pure sedatives whose action cannot be secured until nausea has been occasioned by them. Asthmatic spasm, like every other cramp, rarely holds out against the sickening effect of tobacco, lobelia, or even of ipecacuanha. Tobacco, therefore, is effective only with those who are not used to it. Lobelia has the disadvantage of producing too much prostration, and the same may be said of tartar emetic. This class of remedies works much better in bronchitic than in peptic asthma.

Besides these there are but few nervines left in the pharmacopœia which are not recommended by some for asthma, although no one is ever permanently benefited by any of them.

Better results, however, may be hoped for from efforts directed to other aims than simply to relieve a fit of the dyspnœa when present. Asthma is at no time absent from the asthmatic any more than epilepsy from the epileptic, though the manifestations of either are only occasional. Prophylaxis, therefore, assumes an exceptional importance, because, as in other spasmodic neuroses, the malady becomes inveterate in proportion to the frequency of the attacks. As in the case of epilepsy also, the slightest attacks of asthma are as much to be avoided as the severer ones, if there is to be any hope of the patient becoming ultimately free from them, and hence the exciting causes in each instance should be carefully noted and jealously provided against. In those cases in which the susceptibility to odors indicates the upper respiratory tract as the seat of the irritability, the inhalation of carbolized steam should be tried. The steam should be made to surround the head by the simple device of directing it under an umbrella, held low by the patient himself, so that he may inhale without more effort than in ordinary respiration, because breathing by will is too fatiguing a task to be kept up for long by any one, and it is this fact which accounts for the uniform failure of the many inhalers and atomizers which have been invented during the past century. This treatment should be kept up twice a day for months, the object being to produce a permanent change in the susceptibility of the sensory nerves distributed to the nasal and pharyngeal mucous membranes. Occasionally the vapor of turpentine may be substituted for that of carbolic acid. It is in these cases also that much may be expected from the French procedure, originated by Ducros, of painting the posterior wall of the pharynx with aqua ammoniæ, although, to prevent some being made worse by the irritant fumes, Trousseau recommends inhalations of ammonia first from a vial and then touching the pharynx with a weak solution, to be made stronger as the patient becomes accustomed to it. Trousseau refers the immunity of many patients from visits of asthma so long as they reside in the vicinity of gas-works to the presence of ammonia in the air of the locality; but while this possibly may be operative, yet we would ascribe it more to the unmistakable sedative effect upon the bronchial nerves of air charged with creosote, carbolic acid, and other allied products of wood distillation. It is in this class of patients also that the bromides are useful, owing to their paralyzing the reflex excitability of the pharyngeal nerves. A dose of thirty grains of potassium bromide, with a drachm of Hoffman's anodyne at bed-time, will often ward off a nocturnal visit of the enemy.

It is, however, in bronchitic asthma that prophylaxis is particularly imperative. As comparatively few cases of bronchitis originate from direct irritation of the bronchial mucous membrane, but much more commonly from some partial exposure of the skin to unequal degrees of temperature (see *Bronchitis*), so the particular susceptibility of different cutaneous regions should be tested and preventive measures adopted accordingly. As a general rule, in bronchitis which begins usually with a coryza it is the nape of the neck, while in phthisical cases it is the anterior surface of the chest, and in pharyngeal or tonsillar cases the feet, which are the most susceptible to those impressions of passing cold that set up their special tracks of inflammation or hyperæmia in mucous membranes. After a few days' continuance of the catarrhal state, however, the skin of the whole surface partakes in this specific irritability, so that the patients may become aware of a draught from a distant open door which others do not feel. Many cases of bronchitic asthma, therefore, are promptly relieved by putting on a whole suit of buckskin over a light under-flannel, and wearing the same until settled summer weather. These patients also should guard against nocturnal perspiration about the neck and shoulders, by the use of light flannel instead of cotton or linen night-shirts. Daily inunctions with oil also, applied especially to the feet, and preferably done on rising, do much to lessen the tendency to catching cold. The bronchitis itself, of course, should be treated according to its indications, with especial benefit to be hoped for in asthmatics from the emulsion of linseed oil. We need also only allude here to the importance of making the utmost of the intermediate summer period of mitigation

of bronchitis with many patients before the malady has become too chronic, as that subject is to be fully discussed under its proper head.

Peptic asthma is so much influenced by the state of the alimentary canal that some have spoken of the treatment of asthma in general as if it were mainly a matter of regimen and diet. Indigestible food, even a single meal of such, is to be scrupulously avoided in every form of spasmodic disease. The patient must not endeavor to reconcile his digestive apparatus to any second trial with an offender. Whether the proneness to spasmodic or convulsive disorder be due here to the greater susceptibility of the nerve centres to reflex excitation from the alimentary canal than from any other nerve distribution, or whether the susceptibility is caused by the absorption of nerve poisons generated in some intestinal fermentation, it is unquestionable that any departure from good digestion is to be dreaded in treating such complaints, and in none more so than in asthma. Experience will best teach each one all the particulars as regards what he can and what he cannot eat, and its verdict must be accepted. Moreover, with all asthmatics, the digestive power decreases as the day wears on, and hence the best meal should be taken before the afternoon, while in the evening only the lightest supper should be allowed.

But as the prevention of peptic asthma wellnigh involves the treatment of all the varied forms of dyspepsia, we can direct attention here only in a general way to the subject, for each case is to be managed according to its own indications. We may remark, however, that bismuth appears to be one of the most effective preventives of peptic asthma, probably owing to its antiseptic properties. A good form of administration is in capsules of five grains each of bismuth. carb., and of pulv. calumbæ, two such to be taken an hour after meals and at night. Ten grains of sodium benzoate and ten grains of bismuth salicylate, administered in two capsules, will also often be found effective in preventing intestinal fermentation.

In conclusion, we would recommend, besides prophylactic measures, the recourse to certain remedies whose benefit, when secured, can properly be termed lasting or curative, instead of merely palliative. Want of success with them may be due often to a failure to recognize the fact that to be truly curative in such a deepseated and lifelong malady as asthma a remedy must be given continuously without reference to the attacks, and long enough to produce a decided modification in the system itself. Such a result never can be obtained from nervines, however steadily or largely they be taken, as is proved by the absence of any recognizable sign, either during life or after death, of the years spent by many in consuming tobacco or opium. In arsenic and the potassium iodide, however, we possess truly constitutional medicines, whose value in asthma has been repeatedly demonstrated. If these medicines, however, have any effect on asthma, that effect is wholly different in kind from the immediate relief produced by a transient-acting nervine, for it must be by causing a more or less organic alteration in the lesion itself. Their proper administration in asthma, therefore, should be like the administration of iron for anæmia, or mercury for syphilis, or the bromides for epilepsy, the effect being obtained not by one, or by the first dose, but only after months of steady use. I feel assured that if a combined or alternate arsenical and iodide treatment were as systematically adopted in the treatment of asthma as the above-named constitutional remedies are used in other maladies, many a case of this disease would be finally got rid of which now, under the deceptive recourse to nervines, becomes at last an incurable habit of the nervous respiratory mechanism.

To obtain the best results with constitutional remedies, two therapeutical rules should be steadily followed. The first is to administer along with them one or more of the restoratives, in order to prevent the injurious effects of the continued taking of such unnatural substances into the system as arsenic or iodine. No symptoms of iodism or of arsenic should be allowed, because the remedial effects of these medicines cease at once upon the appearance of any signs of their poisonous operation. If diminishing the dose is not followed by a cessation of the symptoms, these drugs must be omitted for a time, and then resumed in small doses, to be increased again only as the patient can tolerate them. The best restoratives with arsenic are quinine and codliver oil, while phosphorus and the muriated tincture of iron best prevent the injurious effects of iodine.

The second rule is to secure the co-operation of nervines, for though these latter cannot be curative in themselves, yet experience proves that they unquestionably promote the action of constitutional remedies when they relieve some of the symptoms of the disease. Thus I have repeatedly noted potassium iodide fail adequately to cure a syphilitic node until opium and conium were added to the prescription. And on the same principle I have been accustomed in asthma to prescribe a combination somewhat as follows: ℞ Kal. iodid., ʒ iss.; Liq. pot. arsen., ʒ i.; Spts. eth. sulph. co., ℥ iiss., Tr. belladonnæ, ʒ ij.; Spr. aurant. cort. ad ℥ vi. M. S.: Two teaspoonfuls in water an hour after meals.

In a certain proportion of cases a curative effect is secured by counter-irritation applied along the cervical and upper dorsal vertebræ. The actual cautery is to be preferred, and one form of this irritation is both effective and readily applied without expensive apparatus, namely, by the hot glass rod. Spots of ink, half an inch or so apart, made along the spinous processes, are to be lightly touched by the tip of a glass rod raised to a white heat in the flame of an alcohol lamp. This simple procedure causes but little pain, and immediately after the application shows a continuous red line as if made by the passage of a hot iron. The application should be repeated about every fourth day.

If there is any history of the alternation of asthma with the disappearance of a cutaneous eruption, an artificial eczema by croton oil on the chest, as already mentioned, is often positively remedial if persevered in on the first sign of a return of the dyspnœa. Asthma secondary to other diseases must be treated with them. In the cardiac cases, and in gouty patients as well, a continued use of saline waters, like the Congress or Hathorn of Saratoga, will afford the best prospect of relief.

In all cases of asthma, however, a careful examination of the nasal passages should be made at the beginning and repeated throughout the treatment. The innervation of the outlets of all long tubular tracts is closely associated with the nervous mechanism controlling the muscular movements of the whole tract, examples of which are seen in the heightened irritability of the whole genito-urinary apparatus by a narrowed meatus, or orifice of the prepuce, by the pylorus remaining patent so that the stomach is too quickly emptied in dysentery, etc. We need not wonder, therefore, if the normal rhythm of respiration is readily deranged by a polypus or other obstruction in the nose, and all such conditions should be fully remedied when found. But aside from such lesions, many asthmatic attacks may be prevented or aborted early by a spray of carbolized oil—one part of carbolic acid to forty of sweet almond oil—used especially on retiring at night.

William H. Thomson.

ASTIGMATISM* (from *α*, privative, and *στιγμα*, a point) is the name proposed by Whewell (1846) to designate the visual anomaly which results from unequal refraction in the planes of the several ocular meridians.† Accurate measurements of the cornea reveal, in the greater number of eyes, a somewhat different radius of curvature in different meridians, and not infrequently this difference is sufficient to give rise to serious imper-

* The form "*astigmia*," cf. "*presbytia*" = *presbyopia*, has been lately adopted by certain French writers.

† For convenience, the familiar system of lines and circles used in geography is extended to the topography of the eyeball. If we designate the centre of the cornea and the central fovea of the retina as the anterior and posterior poles, respectively, the line connecting them is the axis; all great circles passing through the two poles are meridians; the great circle which cuts all the meridians midway between the poles is the equator; and the portion of the surface included between any two parallels is a zone.

fection of vision. As a rule, the meridian of greatest curvature is vertical or approximately vertical, and the meridian of least curvature, at right angles to the former, is horizontal or approximately horizontal. To this rule there are, however, many and conspicuous exceptions.

The crystalline lens, also, may be the seat of asymmetrical refraction, either through inequality of curvature in its several meridians, or through some deviation from perfect symmetry of position as referred to the axis of the eyeball. Astigmatism of the crystalline lens is generally of comparatively low grade, and the meridian of greatest lenticular refraction is oftenest approximately horizontal, rather than vertical. Hence lenticular astigmatism tends oftener to correct than to increase the astigmatism due to asymmetry of the cornea, and the total astigmatism of any eye is apt to fall short of rather than to exceed that which would result from the corneal asymmetry alone.

From the fact that neither the cornea nor the anterior or posterior lens surface is a perfect surface of revolution, and that not one of these surfaces is quite accurately adjusted with reference to the axis of the eyeball, it follows that the refraction, whether symmetrical or asymmetrical, in any eye is actually the resultant of three more or less asymmetrical refractions. In practice, however, these complications are disregarded, and the investigation of the elements of any case of astigmatism is limited to the measurement of differences in the curvature of the cornea in different meridians and to the study of the refractive phenomena as a whole.

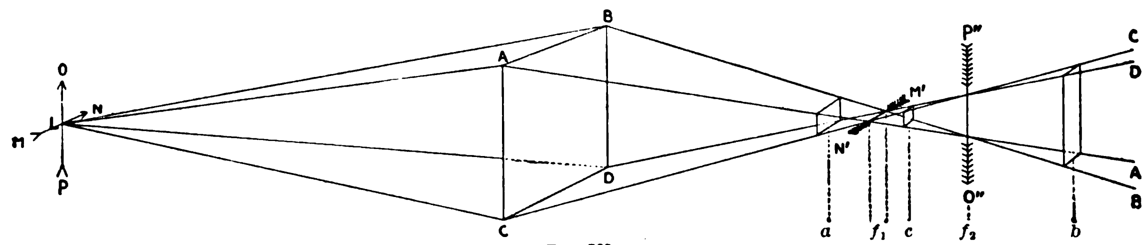


FIG. 336.

The characteristic property of a pencil of light after a single astigmatic refraction (or reflection) is that it has no focus, properly so called, but that all its rays pass through two nearly straight lines, which lie at right angles to the axis of the pencil and to each other (*focal lines*). The construction of such a pencil is shown in Fig. 336, in which L represents a luminous point; A, B, C, D a portion of an asymmetrical refracting surface (cornea), of which the meridian of greatest refraction is assumed to be vertical, and which for convenience in representation is taken as a square; f_1 the first focal line; and f_2, lying in a direction at right angles to the first, the second focal line. The form of the cross section of the pencil at other parts of its course after refraction is indicated by the three parallelograms, *a*, *c*, and *b*. Only one of these cross sections (*c*), lying between the two focal lines but nearer to f_1 than to f_2, has the same form as the cross section of the pencil before refraction (namely, a square); all the others are parallelograms, having their longer sides in a direction parallel to the nearer focal line. The distance separating the two focal lines (f_1 and f_2) is called the *focal interval*.

From the construction it follows that if the pencil is cut by the retina at f_1, the luminous point at L will be seen as a horizontal bright line, and, similarly, if the pencil is cut at f_2, the point L will be seen as a vertical line. If the pencil is cut by the retina at *c*, the point will be seen as a small spot having the form of the refracting surface, which, in the eye, is determined by the form of the pupil, and is therefore approximately circular. If the pencil is cut at any other part of its course the point will be seen as an oval closely approximating an ellipse. The section of the pencil at *c* is called the *circle of least confusion*.

If, instead of a single luminous point at L, we assume a number of points arranged along the horizontal line M L N, these points will be severally projected at f_1, each as a horizontal line, and these lines, overlapping each other in the greater part of their length, will appear fused into a single horizontal line. It follows that the line M L N, which may be regarded as made up of an infinite number of points, will be projected as a horizontal line at f_1. So also a series of points arranged along the vertical line O L P, or the vertical line O L P itself, will be projected as a vertical line at f_2. Lines lying in one or the other of these two directions (parallel to M L N or to O L P) are, in fact, the only objects which can be projected by the asymmetrical refracting surface without conspicuous alteration.

The line M L N and the first focal line f_1 lie in the same plane; similarly the line O L P and the second focal line f_2 lie in a plane at right angles to the former plane. The intersections of these two planes (*principal planes*) with the refracting surface mark the meridians of least and greatest refraction (*principal meridians*), which are also at right angles to each other. It is sufficient, therefore, in any case to note the direction of one of the principal meridians, preferably the meridian of greatest refraction, which, in the case of the cornea, is designated by the symbol M_c.

The phenomena characteristic of astigmatic refraction may be shown experimentally by means of a lighted candle, an ordinary convex lens, and a convex plano-cylindrical lens.* The image of the distant candle flame, which may be considered as equivalent to a luminous point, is first received upon a screen placed at the principal focus of the spherical lens, where it will appear as a bright point. If now the convex cylindrical lens is placed immediately in front of or behind the spherical lens, this bright point will be seen drawn out into a bright line representing the second focal line (f_2), and by moving the screen nearer to the combined lens a distance will be reached at which the bright point will be seen drawn out into a line at right angles to the first, representing the first focal line (f_1). In moving the screen from the position of the second to that of the first focal line, a point will be passed at which the illuminated area is seen expanded into a small circular bright spot, reproducing the circular outline of the lens (circle of least confusion); at all other distances the section of the pencil will be elliptical in form, with the longer axis of the ellipse in the direction of the nearer focal line.†

To study the phenomena of astigmatic vision, it is only necessary to look through a weak cylindrical lens held before the eye or mounted in a spectacle frame. If the eye is emmetropic (see *Accommodation and Refraction*), a convex cylindrical lens will render it short-sighted (myopic) in the meridian at right angles to the axis of the cylinder, and, conversely, a concave cylindrical lens will render it over-sighted (hypermetropic) in the same

* A plano-cylindrical lens has one surface plane and the other ground to a cylindrical curvature, which may be either convex or concave. Lenses are also ground with a convex or concave spherical surface on one side and a convex or concave cylindrical surface on the other side, and may be imitated by cementing together, by their plane surfaces, an ordinary plano-convex or plano-concave lens and a plano-cylindrical lens. Such a combined lens is called a spherico-cylindrical lens.

† If instead of a candle flame a very bright light is used, such as an electric arc or calcium light, or a beam of sunlight directed by means of a mirror through a small hole in the window shutter, the form of the pencil may be seen lighting up the dust of the room along its entire course.

meridian; thus reproducing the two types of simple astigmatism, namely, *simple myopic astigmatism* (Am) and *simple hypermetropic astigmatism* (Ah). If the eye is myopic, or is made so for the experiment by means of a convex spherical lens, the convex cylindrical lens will render it more myopic in the meridian at right angles to its axis; and, similarly, if the eye is hypermetropic, or is made so by means of a concave spherical lens, the concave cylindrical lens will render it more hypermetropic in the meridian at right angles to its axis; thus reproducing the two types, *compound myopic astigmatism* (M + Am), and *compound hypermetropic astigmatism* (H + Ah). A fifth type, called *mixed astigmatism* (Amh or Ahm), is reproduced in the emmetropic eye by looking through a convex or concave spherical lens combined with a concave or convex cylindrical lens of greater power; in the myopic eye, by looking through a concave cylindrical lens of a power in excess of the degree of the myopia; and in the hypermetropic eye, by looking through a convex cylindrical lens of a power in excess of the degree of the hypermetropia. These five types include all the possible varieties of regular astigmatism.

In M + Am all distant objects appear confused and indistinct, but there is a certain distance at which a point is seen under the form of a line corresponding to the second focal line (f_2), and there is a second, shorter distance at which the same point is seen as a line at right angles to the former line and corresponding to the first focal line (f_1). In Am a distant point is seen as a line corresponding to the second focal line (f_2), and a point at some shorter distance is seen as a line corresponding to the first focal line (f_1). In Ah a distant point is seen as a line corresponding to the first or to the second focal line (f_1 or f_2), according as the eye is in a state of rest or is accommodated to a degree equal to the measure of its astigmatism. In H + Ah a distant point is seen as a line corresponding to the first focal line (f_1) through the exercise of some part of the accommodation equal to the measure of the hypermetropia (H), and it may be seen as a line corresponding to the second focal line (f_2) through a greater exercise of the accommodation equal to the sum of the hypermetropia (H) and the astigmatism (Ah). In mixed astigmatism (Amh or Ahm) a distant point is seen as a line corresponding to the second focal line (f_2) through the exercise of some part of the accommodation, and a point at some shorter distance is seen as a line corresponding to the first focal line (f_1).

In any case in which a point is seen under the form of a line, all lines at the same distance which correspond in direction to the direction of this linear image will be seen sharply defined. Hence the visual phenomena in astigmatism may be studied by the use of test objects made up either of points or rows of points, or of lines or sets of parallel lines. Examples of such test objects are

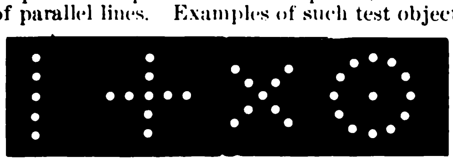


FIG. 367 *a*.

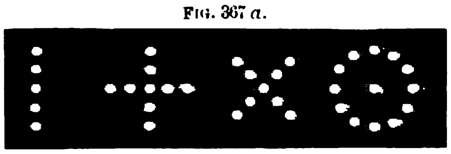


FIG. 367 *b*.

shown in Figs. 367 and 368, both as they are seen by the normal eye when accurately focussed for their distance, and as they appear to an astigmatic eye when similarly adjusted in its vertical meridian. In Fig. 367 *b* every dot is seen elongated and blurred in the horizontal direction, so that the dots in the horizontal rows appear to run into one another, while in the vertical rows they are seen distinctly separated. Similarly the horizontal lines in Fig. 368 *b* are seen sharply defined, although somewhat elongated, while the vertical and oblique lines appear blurred.

In the diagnosis of astigmatism, as of ametropia generally, both objective and subjective methods are employed. In the examination of the eyes of very young

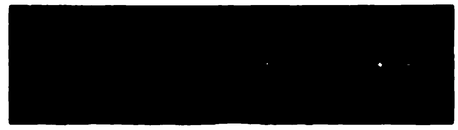


FIG. 368 *a*.

FIG. 368 *b*.

children objective methods are alone available, and in nearly every case they give direct and valuable information by quickly and surely revealing special refractive defects and indicating the way to their further investigation.

For convenience and general applicability the ophthalmometer of Javal and Schiötz (see *Ophthalmometer*) holds a foremost place. By means of this instrument the smallest deviations from symmetrical curvature of the cornea are detected, and both the direction of the meridians of greatest and of least curvature and the difference in the corneal refraction in these meridians are measured with great accuracy and with great economy of time. Working from these corneal measurements as a starting point, the way to the determination of the refraction of the eye as a whole is shortened and made clearer, and in the end a more comprehensive diagnosis is reached than is possible when the corneal astigmatism is ignored as a distinct factor.

The ophthalmoscope is used in several different ways for the detection and measurement of refractive anomalies, including astigmatism. In viewing the fundus of the eye in the erect image (see *Ophthalmoscope*), the details of the picture of the retinal vessels and optic disk are affected in the same manner as are the images of visible objects when viewed by an ametropic eye. In astigmatism the retinal vessels afford, to the observer, test objects not unlike the radiating lines shown in Fig. 368; the determination of the refraction in the two principal meridians is made by noting the strongest convex or the weakest concave lens through which the observer sees distinctly the vessels which lie at right angles, respectively, to the direction of these meridians. In the higher grades of astigmatism the fundus of the eye presents a very characteristic picture of a confused red ground marked by parallel streaks of a deeper red, in which the double contour of a retinal vein or artery is here and there recognizable, and by a lighter spot, the optic disk, which is seen elongated and blurred in the same direction. The inspection of the details of the fundus is best made with the ophthalmoscope devised for this purpose by Loring, in which a revolving disk (or disks), containing a large series of convex and concave lenses, is mounted immediately behind the mirror. To secure a good observation it is often convenient, and sometimes necessary, to dilate the pupil, but not, as a rule, to paralyze the accommodation. Cocain hydrochlorate (three per cent.) and euphthalmin hydrochlorate (five per cent.), or a solution of the two salts (one per cent. each),* afford a choice of mydriatics which best fulfil this indication.

Another application of the ophthalmoscope to the investigation of the refraction is by the method known as retinoscopy, shadow test, etc., which consists essentially in the observation of the direction in which the dark

* As recommended by E. Jackson.

border of the image of a flame, reflected into the eye by the mirror, moves across the strongly illuminated pupil (see *Shadow Test*). By this method measurements of the total refraction of the eye, and, in astigmatism, of the direction of the principal meridians and also of the refraction in each of these meridians, may be made with a fairly close approximation to accuracy. Preliminary dilatation of the pupil is always a help, and is often indispensable; cocain hydrochlorate and euphthalmin hydrochlorate are to be preferred for this purpose. For the indication of other methods by which the ophthalmoscope may be helpful in the detection and investigation of astigmatism, see *Ophthalmoscope*.

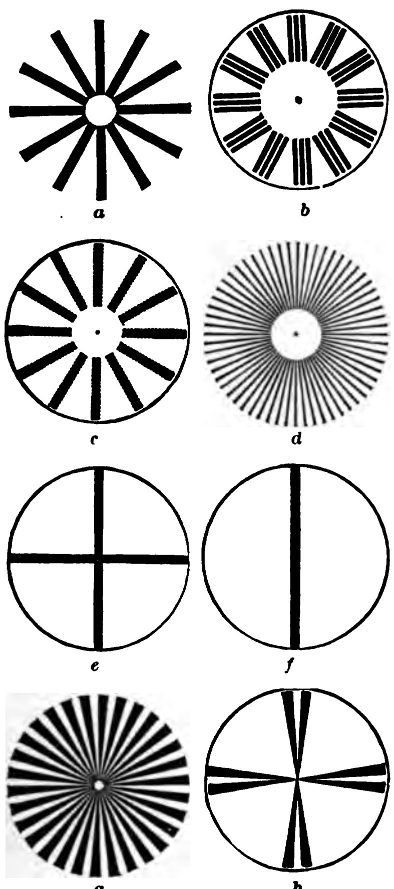


FIG. 369.

The subjective investigation of astigmatism is most directly and easily conducted by the use of special test diagrams similar to the test objects shown in Figs. 367 and 368. A few examples, selected from a much larger number which have been devised for this purpose, are shown in Figs. 369, *a* to *h*. They are printed on circular cards, about nine inches in diameter, and, for greater convenience in use, and to meet the varied conditions in different cases, they are drawn to different scales; the finer lines are easily distinguished by a normal eye at a distance of about eight metres. The several cards are made with a central hole, so that they may be made to turn on a pivot at the centre of a larger card representing a clock dial. This dial card is hung on the wall, in a good light, and the tests are viewed from the opposite side of the room at a distance of about five or six metres. When an astigmatic eye is directed upon one of the diagrams made up of radiating lines or sets of lines (Fig. 369, *a* to *f*) or of narrow sectors (Fig. 369, *g*, *h*), the lines or sectors which correspond in direction to one of the two principal meridians are generally seen more sharply defined than those in the other meridians. In simple myopic astigmatism (Am) the line or lines corresponding in direction to the ocular meridian of greatest refraction (M_o) are seen clearly defined, while those in the other meridians appear indistinct or confused. In mixed astigmatism (Amh or Ahm) the lines which correspond in direction to the meridian of greatest refraction are distinguished through an exercise of the accommodation equal to the measure of the hypermetropic part of the refractive anomaly, while those in the other meridians are seen indistinctly. In simple hypermetropic astigmatism (Ah) the lines corresponding in direction to the ocular meridian of least refraction (at right angles to M_o) are seen distinctly when the eye is in a state of accommodative rest, and these lines become confused, while those corresponding in direction to the meridian of greatest refraction (M_o) become in turn distinct, when the accommodation is exerted to a degree equivalent to the measure of the astigmatism. In compound hypermetropic astigmatism (H + Ah), the lines in the former or in the latter of these meridians are seen sharply defined, through an exercise of the accommodation equivalent in the one case to the measure of the hypermetropia (H), and in the other case to the measure of the combined hypermetropia and astigmatism (H + Ah). Only in compound myopic astigmatism (M + Am) do the lines necessarily appear indistinct in all meridians, although least so in the meridian of greatest ocular refraction; when the myopia (M) is corrected, by placing a suitable concave lens in front of the eye, the case is transformed into that of simple myopic astigmatism (Am).

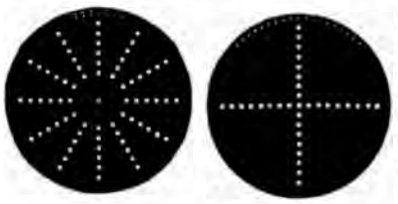
In the hypermetropic forms of astigmatism (Ah, and H + Ah), and also in certain cases of mixed astigmatism, the examination is rendered difficult by unconscious accommodative efforts of the patient in the attempt to recognize as many as possible of the test lines. To overcome this difficulty it is generally necessary to suppress the accommodation for the time being, which may be accomplished by placing before the eye a convex glass of sufficient strength to correct it in its meridian of least refraction; in other words, bringing the eye into the condition of simple myopic astigmatism (Am), by making it look through the strongest convex glass through which it can clearly distinguish the lines in any meridian. The disturbing influence of the accommodation may also be annulled by means of a solution of atropia, several times instilled, until the accommodation becomes completely paralyzed. This involves, however, a serious disturbance of vision, which may persist for many days, and also the special disadvantage of enlarging the pupil far beyond its normal diameter, and so including in the measurement a peripheral zone of the cornea and of the crystalline lens, in which the curvature may differ materially from that in the central region which alone is ordinarily utilized in vision.*

In the investigation of any case of ametropia by this method, we first select, by successive trials, the weakest concave glass (in M + Am) or the strongest convex glass (in Amh or Ahm, Ah, and H + Ah) through which the lines in any meridian are clearly distinguished. If the lines in all the meridians are seen through this spherical glass with perfect distinctness, astigmatism is excluded. If the lines in only one meridian are distinctly recognized this meridian will be the ocular meridian of greatest refraction (M_o), and the glass through which the lines are seen will represent the measure of the ametropia (M or H) in the ocular meridian of least refraction. When these two elements have been determined, it remains only to ascertain the degree of astigmatism, by successive trials with concave cylindrical glasses, until a glass is found through which (when added to the spherical glass already chosen) the lines in both principal meridians are seen clearly. This cylindrical glass is the measure of the astigmatism.

Proceeding in this manner, we obtain a formula in terms of M + Am, Am, or H + Am; the symbol M + Am being that of *compound myopic astigmatism*, and Am that of *simple myopic astigmatism*. In the expression H + Am, we may have H = Am, in which case the expression reduces to Ah, which is the symbol of *simple hypermetropic astigmatism*. When H > Am, the expression H + Am is transformed into H + Ah, the symbol of *compound hypermetropic astigmatism*, by taking H equal to the difference in the numerical values of H and Am and changing Am to Ah. When H < Am, the case is one of *mixed astigmatism* (Amh or Ahm), and the expression H + Am

* Measurements of the refraction made under artificial paralysis of the accommodation ought never to be adopted as final until they have been verified, or corrected, by other tests made after the last traces of mydriasis have disappeared.

may be converted at will into the alternative form, M + Ah, by taking M equal to the difference in the numerical values of H and Am and changing Am to Ah. The form H + Am (= Amh), is commonly used when $H < \frac{1}{2}Am$; the alternative form M + Ah (= Ahm) is used when $H > \frac{1}{2}Am$. Test objects made up of arrangements of points or dots are best made by punching holes in a sheet of cardboard, to be hung in a window against a background of ground glass or of white or colored (yellow or red) tissue paper (Fig. 370). The astigmatic eye sees each bright



a   b

FIG. 370.

a   b

FIG. 371.

dot elongated in the direction of one of its principal meridians, and if the test object is viewed through a spherical lens, selected as in the case of examination by the aid of the diagrams with radiating lines, the elongation will be in the direction corresponding to the ocular meridian of greatest refraction (M_o). If now the attention is directed to the row of dots lying in this meridian, the several dots will appear as if fused together in a bright streak, whereas in the other principal meridian

a   b

FIG. 372.

(corresponding to the ocular meridian of least refraction) they will be seen distinctly separate from one another, and can be easily counted. Transparent test objects may also be made with radiating lines, either bright lines on a dark ground or dark lines on a bright ground (Fig. 371). Owing to the strong irradiation, the contrast between the lines in the several meridians is much more conspicuous than in the case of the printed diagrams, but by using one or more thicknesses of tissue paper for the background, we may reduce the irradiation to any degree that may be found most advantageous. A useful test object may also be made with translucent red (carmine) radii on a translucent blue (ultramarine) field, separating the two colors by narrow dark lines (see *Optometry*); the radii which lie in the plane of the ametropic meridian are seen in their proper color, while the others appear of a combination (purple) tint. Test objects may also be constructed of circles instead of radii, or of combined radii and circles (Fig. 372); or lines of different degrees of inclination may be arranged in a linear series (Fig. 373), or as in the striped letters devised by Pray. Advantage may also be taken of the property of certain letters or figures to take on confusing shapes under the influence of astigmatic refraction.

A stellate arrangement of very fine lines may be used as a test for astigmatism by placing it at or near the principal focus of the convex lens of an optometer (Burow). The best apparatus for this purpose is the binocular optometer of Javal, in which the two eyes are severally directed, with their axes parallel, upon two small figures, like watch dials, corresponding to the two pictures on a stereoscopic slide (Fig. 374). Upon one of the dials are engraved the hours, and the star of fine

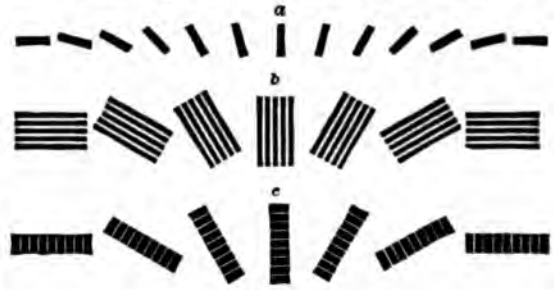


FIG. 373.

lines; besides these there are a number of circles and lines common to both dials, to facilitate binocular fusion of the two pictures. The radiating lines are thus viewed by only one of the eyes, while the other eye is fixed upon the second dial. The card with the two dials is placed in the optometer (or in a stereoscope fitted with a sliding holder), at a distance from the lenses well within their principal focus, and is then moved slowly away until all the radii except those in one meridian become indistinct; this meridian corresponds to the ocular meridian of greatest refraction (M_o), and the measure of the refraction for this meridian is the difference between the power of the convex lens (in dioptries) and that of a lens having a focal length equal to the greatest distance at which the line in question is distinctly seen. The measure of the astigmatism is obtained by successive trials with concave cylindrical lenses, brought in front of the lens of the optometer (or stereoscope), until a glass is found through which all the radii are seen clearly defined. Having measured one of the eyes in the manner described, the card is exchanged for another with transposed dials and the other eye tested in its turn.

The *stenopæic apparatus*, which is simply a thin plate of blackened metal perforated by a narrow slit, may be

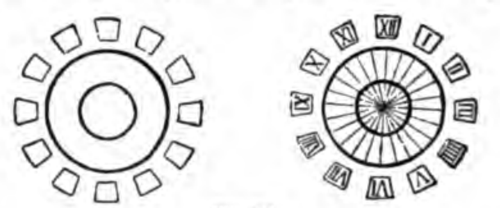


FIG. 374.

used to shut out from the eye all rays except those which lie in the plane of the meridian of the slit. In this way it is possible to measure in succession the refraction in the two principal ocular meridians by the use of spherical glasses. The stenopæic slit is often useful in the first approximate diagnosis of complicated cases of astigmatism, but the method is greatly inferior in accuracy to those in which cylindrical lenses are employed.

The optical correction of astigmatism is by wearing a spectacle lens of asymmetrical refraction, of such power and so mounted as to equalize the refraction of the eye in its two principal meridians. The simplest form of lens for this purpose is a plano-cylindrical lens, mounted so that the axis of the cylindrical surface shall lie in the plane of the ocular meridian of greatest refraction (M_o) when the cylindrical surface is convex, or in the plane of the meridian of least refraction (at right

angles to M_o) when the cylindrical surface is concave. A convex plano-cylindrical lens in the case of simple hypermetropic astigmatism (Ah), or a concave plano-cylindrical lens in the case of simple myopic astigmatism (Am), corrects the entire refractive error and so reduces the eye to the condition of emmetropia (E). In all other cases the effect of any plano-cylindrical lens which corrects the astigmatism is to reduce the eye either to simple hypermetropia (H) or to simple myopia (M). To correct this residual hypermetropia or myopia a convex or a concave spherical surface, of appropriate radius of curvature, may be ground on the back of the plano-cylindrical lens, thus making a spherico-cylindrical lens suited to the correction of the total refractive error.

In any case of astigmatism, the equalization of the refraction in the two principal meridians may be effected either by a convex cylindrical or by a concave cylindrical lens, as may be preferred. Thus, in Am, we ordinarily prescribe a plano-concave cylindrical lens; but we may, at pleasure, prescribe an alternative form of lens combining a convex cylindrical with a concave spherical surface of equal (negative) power. In M + Am, we ordinarily prescribe a lens combining a concave cylindrical with a concave spherical surface; but we may, at pleasure, prescribe an alternative lens in which a convex cylindrical surface is combined with a concave spherical surface of a (negative) power equal to the sum of the (negative) powers of the concave cylindrical and the concave spherical surfaces in the former combination. In mixed astigmatism (Amh or Ahm), we may, at pleasure, combine a concave cylindrical with a convex spherical surface, or a convex cylindrical with a concave spherical surface. In all these cases there may be a positive advantage in prescribing a lens with a concave spherical surface turned toward the eye, thus approximating, more or less closely, the concavo-convex form of lens. In Ah we may, at pleasure, prescribe a plano-convex cylindrical lens, or a lens in which a concave cylindrical surface is combined with a convex spherical surface of equal power. In H + Ah we may similarly choose between a lens in which a convex cylindrical surface is combined with a convex spherical surface, or a lens in which a concave cylindrical surface is combined with a convex spherical surface of a power equal to the sum of the powers of the convex spherical and the convex cylindrical surface in the first combination. In these alternative combinations the meniscus form of lens is partially realized, and some advantage may be obtained by mounting the concave cylindrical surface toward the eye.

The greatest freedom of choice in the selection of the best form of lens, in any case of astigmatism, is afforded by the use of lenses in which one of the surfaces is ground to a curvature of unequal radii in its two principal meridians. Such lenses, having either a convex or a concave surface ground to the configuration of a segment of a torus,* may be made of any required radius of curvature in each of the two principal meridians. The difference in power in the two meridians represents the required correction for the astigmatism, and the power of the lens in one or the other of these meridians represents the correction for any residual hypermetropia or myopia. A concave toric combined with a convex spherical surface, or a concave spherical combined with a convex toric surface, may be prescribed for the correction of any case of simple, compound, or mixed astigmatism. Such a lens, with the concave surface (spherical or toric) turned toward the eye, may be so proportioned as to realize fully the particular advantages derivable from the periscopic (concavo-convex or meniscus) form of lens. Lenses may also be ground with two unequal cylindrical surfaces with crossed axes, but such lenses do not differ in effect from those in which a spherical and a cylindrical surface are combined.

Any lens set obliquely to the direction of a pencil of rays refracted through its centre develops an increase of power in all meridians, but most in the meridian cut by the common plane of the axis of the pencil and the axis of the lens. A convex or concave spherical spectacle lens may thus have its power so increased in its vertical meridian, by tilting it forward, as to render it equivalent to a lens of somewhat greater power combined with a cylindrical lens with its axis horizontal. This property of lenses is sometimes utilized, intentionally or unintentionally, in cases of compound myopic astigmatism (M + Am), when the ocular meridian of greatest refraction is vertical, and in cases of aphakia after cataract extraction, when, as is oftenest the case, the meridian of greatest refraction is horizontal (see *Spectacles*).

As the ordinary spherical glasses, convex or concave, worn in hypermetropia or myopia, have the incidental effect of increasing or diminishing the apparent size of objects, so the effect of a convex or concave cylindrical glass, worn for the correction of astigmatism, is to increase or diminish the apparent magnitude in the direction at right angles to its axis. Thus a circle is made to appear as a somewhat elongated or as a somewhat compressed ellipse, a square as an elongated or shortened parallelogram, etc. This distortion, which is in proportion to the power of the cylindrical glass required to correct the astigmatism, may cause temporary annoyance; or, in the case of unequal or unsymmetrical correction of the two eyes, it may give rise to special stereoscopic illusions. Errors of judgment from this cause are, however, speedily corrected, as the patient becomes accustomed to the new conditions (see *Spectacles*).

As a consequence of the impairment of the acuteness of vision incident to the higher grades of astigmatism, an astigmatic person may be compelled to hold his book very near to the eyes in order to distinguish the smaller sizes of print. The effort to improve the recognition of special details of the object, through rapid changes in the accommodation, may also be a cause of fatigue. Particular forms of astigmatism may, therefore, contribute materially to the development of asthenopia, either accommodative or muscular (see *Asthenopia*), of excessive accommodative tension and progressive myopia (see *Accommodation and Refraction*, *Myopia*), or of convergent or divergent strabismus (see *Strabismus*).

Irregular Astigmatism.—Under this title Donders has included all visual defects due to irregularity in the general form or in the surface of the cornea, and also to inequality in the refraction of the crystalline lens in its different sectors, and in different parts of the same sector.

Some degree of irregular astigmatism is present in every eye, and must, therefore, be regarded as *normal*. Under this head falls the irregularity in refraction which results from the partial scattering of the rays of light in passing through the crystalline lens. If we prick a very small hole, with the point of a fine needle, in a card, and, holding it a little within the anterior focus of the eye (14.8 mm. = 0.6 inch in front of the cornea), look through the hole at a bright light, the shadow of the pupillary opening and of the central portion of the crystalline lens will be thrown upon the retina and will be seen as delineated in Fig. 375 (Donders). If now we move the card slowly away from the eye, this picture will change gradually to the familiar figure which we call a star, and which we see when we look at a star in the heavens, or at a distant point of light. If, instead of a luminous point, we look at a minute speck of white pigment on an intensely black ground, the speck will appear multiple (*polyopia monophthalmica*), with indications of a stellate arrangement, as in Fig. 376 (Helmholtz).

If we look, with a single eye, at a disk made up of concentric circles, as in Fig. 377 (after Helmholtz), the circles will appear wavy and confused in particular sectors of the disk, and also abruptly bent or broken along the radii which separate one sector from another. From this and from the preceding experiment it is evi-

* Torus is a word used in architecture to designate a moulding, of convex cross section, carried around the base of a column. In geometry, a torus, or tore, is the surface generated by the revolution of a circle about a right line in its own plane; when the right line is taken outside the circle the torus has the form of a ring—anchor ring. A strip of metal of this cross section, (, bent around a cylinder, takes the form of an equatorial zone of a torus, and may be used as a tool for grinding either a concave or a convex toric lens surface.

dent that the eye does not focus a point sharply upon its retina, but rather as a small group of points, each one of which is seen somewhat expanded and distorted, or, in

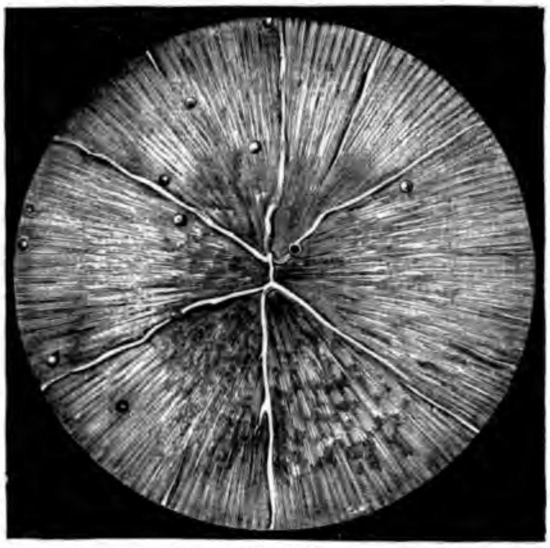


FIG. 375.

the case of a bright point, as a star-shaped figure made up of a number of points more or less completely fused together and rendered still more complex by innumerable fine radiating lines. Thus, a brilliant fixed star or planet is seen as of very conspicuous magnitude, whereas the image of a fixed star in the most powerful telescope is but an intensely bright point of inappreciable diameter. A white dot, line, or letter on a black ground is similarly seen expanded, and is therefore visible at a greater distance than a black object of the same size upon a white ground; on the other hand, the form of the black object on a white ground may often be recognized at a greater distance than that of the bright object on a black ground. This phenomenon is called *irradiation*. The phenomena of normal irregular astigmatism are complicated also by aberration of curvature, in so far as the configuration of the cornea and of the crystalline lens varies from the theoretically perfect curvature requisite for the refraction of incident rays to a single focus, as well as by the slight inequality of refraction in different meridians, which is demonstrable in almost every eye, and which must, therefore, be considered as *normal regular astigmatism*. Hence the retinal image of a star is actually seen a little more expanded than it would be as a result of the scattering of the rays of light in traversing the crystalline lens, and, in the presence of regular astigmatism, the star is also seen elongated.

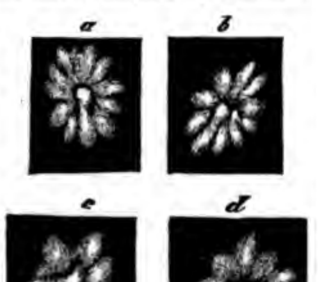


FIG. 376.

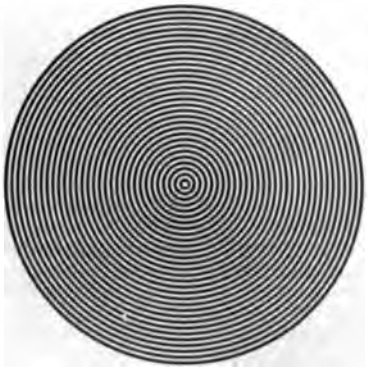


FIG. 377.

Abnormal irregular astigmatism attains perhaps its highest grade in conical cornea (*staphyloma pellucidum*), in which affection it may be a source of very great confusion of vision. Inflammatory processes in the cornea may lead to softening and consequent irregular distention of that tissue; and changes of curvature, both partial and total, may follow the cicatrization of corneal wounds, incisions made in operations, ulcers, etc. In all these cases the disturbance of vision may often be resolved in part into regular astigmatism, and sight may then be materially improved by wearing appropriate cylindrical glasses; in other cases the definition of objects is much improved by looking through a small hole or narrow slit punched in a blackened card or in a thin plate of metal; in rare instances it may be justifiable to attempt to change the position of the pupil by the operation of *iriddesis* (Critchett).

Abnormal irregular astigmatism, with multiple vision, may occur as a result of changes in the crystalline lens, incident to the incipient stages of cataract; myopic refraction also may be developed at the same time, probably through an increase in the curvature of the lens surfaces. *John Green.*

ASTRINGENTS.—Astringents—from *ad* (to) and *stringo* (I bind)—are agents which, acting locally, produce condensation and corrugation of tissues by precipitating their contained albumin and gelatin, and by diminishing the amount of fluids present in protoplasm. They also cause contraction of living muscular fibre, possibly by direct irritation. Secretion from mucous membranes and from denuded surfaces is lessened by astringents which produce a constricting effect upon the capillary blood-vessels and also perhaps at the same time upon the glands and their ducts. All the astringents except alcohol produce some sort of chemical action which promotes destructive metamorphosis. Alcohol, on the other hand, retards these retrograde changes in the tissues. The subdivision into vegetable and mineral astringents is recognized and their action is either local or remote. Astringents are said to act locally when they are applied directly to a part upon which it is desired to produce this particular kind of effect. On the other hand, they act remotely when they are taken into the circulating blood and are thus brought in contact with certain internal (remote) organs. Among the astringents which are used in this way are dilute sulphuric acid, gallic acid, lead acetate, etc. According to some authorities this mode of action of astringents is precisely the same as that which takes place when the remedy is applied locally, in the ordinary direct manner. Intestinal and urinary astringents are terms which are applied to certain drugs which exert a special astringent influence upon these organs of the body; the former contracting the walls of intestinal vessels and constringing the intestinal mucous membrane, while the latter manifest their influence mainly by diminishing the excretion of urine. Astringents are administered internally in the form of solutions, pills, or powders.

Vegetable astringents depend for their action upon the contained tannic and gallic acids. Tannic acid is said to be digallic acid anhydride. It is a crystalloidal substance, a glucoside, having the formula $HC_{14}H_9O_9$. It combines with colloids, precipitates pepsin, and coagulates albumin and gelatin. In this respect it differs from gallic acid, which does not coagulate either albumin or gelatin, and which is therefore better adapted for internal use. In fact, before tannic acid can be absorbed it must be converted, in the system, into gallic and pyrogallic acids. Arranged alphabetically, the vegetable astringents are: alnus, castanea, catechu, diospyros, galla, geranium, granatum, hamamelis, hæmatoxylon, heuchera, kino, krameria, myrica, nymphea, quercus alba,

rhus glabra, rosa glabra, rubus statica, uva ursi, and all other substances which contain tannic acid. Among the mineral astringents may be mentioned: the dilute acids (acetic, carbolic, muriatic, nitric, sulphuric), alcohol, alum, bismuth subnitrate and other bismuth salts, cadmium sulphate, chalk, cocaine, cerium oxalate, copper sulphate, creosote, ferric chloride and ferric persalts, lead acetate and subacetate, zinc preparations, especially the oxide and the sulphate, and several other metallic salts.

Astringents are valuable styptics and hæmostatics, and they also harden and restore tone to relaxed tissues. They cause capillary vessels to contract, and they constrict glands and their ducts. They exert some control over inflammation and they diminish the secretion from mucous membranes and from denuded surfaces. They excite contractions in muscular fibre, and they cause spongy granulations to wither away. When applied to an ulcerated or denuded surface they bring about (through coagulation of the protoplasmic albumin) the formation of a pellicle which covers and protects this surface from the atmosphere and from external irritants. Thus, pain is lessened at the same time that healing is promoted by astringents. When they are administered internally, their action is either local, or, like tonics, which they somewhat resemble, they impart vigor and tone to various structures of the body. Thus, upon the nervous system they may exert a decided and oftentimes a beneficial influence. They diminish peristaltic action to some extent. With three exceptions all astringents irritate more or less. They are therefore contraindicated in acute inflammation. The three sedative astringents are lead acetate or (subacetate), cerium oxalate, and bismuth subnitrate.

Synergists: Tonics, especially the bitter tonics, also those agents which increase retrograde metamorphosis.

Antagonists and Incompatibles: Vegetable astringents are incompatible with the "ic" and "ous" salts of iron, also with the salts of antimony, copper, lead, silver, and zinc; with alkalies, alkaloids, and glucosides; and with pepsin, albumin, gelatin, emulsions, and the mineral acids.

Manner of Elimination from the System: Tannic acid is excreted by the bowels as gallic or pyrogallic acid. It is also eliminated by way of the kidneys.

Uses and Therapeutic Applications: To check excessive secretion from the skin, as in hyperidrosis or in night sweats; to check secretion from mucous membranes, as in the various catarrhs (nasal, buccal, bronchial, intestinal, urethral, vesical, vaginal, etc.); to lessen secretion from denuded and ulcerated surfaces. It must always be remembered that astringents are not to be used until the inflammation reaches that stage in which the secretion from the inflamed part is beginning to be excessive. Capillary oozing or hemorrhage from some remote organ, as from the kidney or bowel, may be controlled by the astringents; gallic acid being preferable to tannic in such cases. Diabetes insipidus and albuminuria are other pathological conditions in which the use of gallic acid is indicated. Where the part can be directly reached, as in epistaxis, hæmatemesis, hemorrhage from lower bowel, hemorrhoids, rectal fissure or ulcer, prolapsus ani, subacute or chronic conjunctivitis, otorrhœa, etc., tannic acid is preferable to gallic. In bed sores or when excoriation is taking place, as in dermatitis and intertrigo, alcohol, bismuth, or tannic acid will be found useful as a means of hardening the skin. Finally, since tannic acid is chemically incompatible with the alkaloids and glucosides, it may serve as a useful chemical antidote in poisoning from these active principles. It accomplishes this good effect by throwing down a very slowly soluble, or entirely insoluble, therefore inert, tannate of the alkaloid or glucoside in question. *Leon L. Solomon.*

ATAVISM. See *Reversion.*

ATELECTASIS.—(Synonyms: Apneumatosis; collapse of lung.) The term *atelectasis* (ἀτελής, imperfect, and ἔκτασις, dilatation) is used to designate all non-inflammatory conditions by which either the whole or sharply defined portions of the lungs are undistended by air. Two forms are recognized: congenital and acquired atelectasis.

In some new-born babies, more or less extensive areas of the lungs are unexpanded by the forcible extrance of air into the alveoli. This condition, which is normal in fetal life, becomes pathological when it continues after birth, and is named *congenital atelectasis.*

In other cases, although the respiratory functions have been thoroughly established, collapse is induced as a consequence of some mechanical impediment to the movement of air through the bronchi; and a tract of lung of variable extent becomes again condensed and airless, as in the fetal state. This is called *acquired atelectasis* or *collapse of the lung.* There are two varieties: collapse from obstruction and collapse from compression.

Atelectasis is comparatively rare in adults, but is quite common in infancy and childhood, especially during the first few months of life. A considerable percentage of the mortality in infants is attributable to this cause. The liability to the occurrence of pulmonary collapse adds gravity to all diseases, but especially to those of the respiratory organs at this period of life.

ETIOLOGY.—Congenital atelectasis is not commonly due to vice or disease of the pulmonary organs, but is produced by any condition which prevents the prompt and efficient establishing of the function of respiration after birth. It may be the result of causes which have been in operation during the intra-uterine life of the child, or which have originated during or immediately succeeding birth. Physical weakness, premature birth, placental separation, compression of the cord, protracted labor, and kindred conditions are common causes of atelectasis. It is also not infrequently due to plugging of the bronchioles by liquor amnii and mucus, sucked in by efforts at respiration before the head has cleared the maternal passages. Intracranial effusions pressing upon the pneumogastric, the result of severe protracted or instrumental deliveries, may be placed among the rarer causes of this affection in the new-born.

Atelectasis from obstruction is always secondary to some disease or accident which interferes mechanically with the access of air to the lung cells. The lodgment of a foreign body in a bronchus may result in alveolar collapse. In the vast majority of instances this impediment is the presence of mucus in the bronchial tubes, the effect of an acute or chronic bronchial catarrh, and collapse is therefore a frequent complication of those diseases, like pertussis and measles, in which bronchitis is a part of the natural history.

Whenever one or more terminal bronchioles are occluded by viscid mucus and swelling of the mucosa, the collapse of that portion of the lung fed by the obstructed tube inevitably takes place as soon as the imprisoned air is expelled or absorbed. This purely mechanical explanation of collapse, first advanced by Gairdner of Edinburgh and adopted by nearly all writers on the diseases of children, has been challenged by Holt and others.

Weakness of the inspiratory muscles, and the consequent inability to overcome the obstacles in the tubes, is a powerful auxiliary factor in bringing about collapse, and hence any condition which decreases the physical vigor of the child strongly predisposes to this accident. It is, therefore, a common malady among those enfeebled by a bad inheritance, by chronic and wasting diseases, or by unsanitary surroundings. Rickets also plays an important rôle in the causation, associated as it is with softening of the ribs and narrowing of the thorax.

External pressure may render a lung, or any portion of it, airless (*atelectasis from compression*). Intrathoracic growths or exudations, spinal deformities, and upward displacement of the diaphragm by abdominal tumors or effusions may cause collapse of such portions of the lung as are subjected to pressure.

MORBID ANATOMY.—The collapse may involve considerable areas of the lung (*diffuse atelectasis*), or it may be

limited to small and scattered patches (*lobular atelectasis*). These varieties are found in both the congenital and the acquired forms of the disease, but in the former the lesion usually involves larger tracts of tissue, the half, or even the whole, of one lobe; it is most frequently observed in the posterior and inferior portions of the lungs, in the tongue-shaped projections, and in the apices; while in acquired atelectasis the patches are oftener limited to isolated lobules or groups of lobules, and are more widely disseminated through the parenchyma of both lungs.

The collapsed portions are depressed below the general surface of the lung, feel tough and dense, like soft leather, and are of a dark blue or steel color. They are airless, do not crepitate upon pressure, and sink readily when thrown into water. When they are incised, the section is smooth, non-granular, and, if scraped, exudes a small quantity of bloody serum. After death, if the lesion is recent, the atelectatic portions can be readily inflated through the bronchus, and instantly assume the color and qualities of normal lung; but after some time has elapsed, they undergo changes which destroy their dilatability, and eventually end in the total disappearance of the vesicular structure. The pleura is normal in uncomplicated cases.

When a considerable tract of lung is disabled, important changes ensue in the unaffected tissues and also in the organs of circulation. Pulmonary emphysema is a common sequel. The impediment to the movement of the blood through the lungs results in stasis in the pulmonary artery and the entire venous system, and leads to hemorrhagic infarctions and œdema of the unaffected lung tissue. The same condition also tends to prevent, in congenital cases, the closure of the fetal channels of circulation, especially the foramen ovale.

Symptoms and Course.—The symptoms of atelectasis are chiefly those of "inefficient breathing and incomplete decarbonization of the blood." They exhibit varying degrees of severity in proportion to the rapidity of development and the amount of lung tissue involved. When the collapse is limited to scattered lobules, the symptoms are by no means marked or distinctive. But, on the other hand, if it be so extensive as suddenly to arrest the function of a large part of both lungs, death may take place almost instantly. This occasionally occurs in whooping-cough or capillary bronchitis, affecting feeble, young children.

The symptoms of congenital atelectasis are usually present from birth. In a large majority of instances the infant is born more or less deeply asphyxiated, respiration is established with difficulty and is notably inefficient, but not always, for occasionally the child, although less vigorous than usual, exhibits no serious lung symptoms for some days or weeks after birth.

The literature of the subject furnishes numerous examples of children who have lived for several weeks with a considerable portion of the lung—even an entire lobe—atelectatic, and so altered in structure as to be incapable of inflation after death.

A noted case is reported by Dr. Ryan (London *Lancet*, vol. i., 1868.) A child, aged five weeks and in good condition, died suddenly. At the coroner's inquest, both lungs were found shrunken, inelastic, non-crepitant on pressure, and presenting in every particular the usual appearances of fetal lung. They sank in water, and when they were cut into many pieces no portion of them floated. The microscope showed an absence of cellular structure. Holt comments on the frequency with which the discovery is made that a child, using less than one-half of its lung tissue, has lived for months without showing marked signs of cyanosis.

The breathing is fast and shallow. The child lies quietly without attempting muscular movements, and his whole demeanor indicates lack of vigor. Most of the time is passed in sleep. The cry is not loud and strong, but is a piteous moan or mere whimper, and at times almost inaudible. The child nurses feebly or not at all. The surface, especially the face and finger tips, become cyanotic and the extremities cold. The temperature is normal or subnormal, and the pulse feeble and rapid. The fontanelle is depressed.

In the unfavorable cases, these symptoms become more pronounced, and muscular twitchings foreshadow the coma or convulsions which so often immediately precede the fatal termination. It is not at all uncommon for still-born children who have been resuscitated with difficulty, perhaps by the prolonged use of artificial respiration, to die suddenly after a feeble existence of a few hours or, at most, a day or two. In many of these cases, even when the breathing has been apparently thoroughly established and the cries fairly strong, the post-mortem examinations have shown that only very limited portions of the lungs had been inflated. The autopsy usually reveals a patulous foramen ovale and sometimes thromboses of the cerebral sinuses.

Acquired atelectasis is always a secondary affection, and the symptomatology is largely influenced by the antecedent disease. As previously stated, it almost invariably occurs as a complication of primary bronchitis, or of one of those specific diseases of which bronchial catarrh is an essential element. When collapse of a considerable area of lung occurs in the course of a pulmonary catarrh, the symptoms at once assume a graver physiognomy. The breathing is more hurried, very shallow, and altered in rhythm; the respirations sometimes number from 70 to 80 in the minute. The child grows more restless, the lips become cyanosed, the extremities cold, and the whole appearance indicates profound depression. The temperature falls below normal. The nares dilate widely with each inspiration. The suprasternal depression, and the deep sulcus around the base of the chest which forms with every inspiration, attest the physical difficulty of getting sufficient air into the lungs. When these symptoms are present, unless the obstruction in the bronchial tubes is promptly removed, permitting the free access of air to the closed vesicles, the child sinks into a state of stupor, and dies asphyxiated or in convulsions. Such severe symptoms are, however, exceptional. In most cases, the collapse involves only scattered lobules, and is indicated by symptoms similar to those just enumerated, but less violent.

The physical signs of atelectasis vary with the extent of the lesion. If several contiguous lobules, or the greater part of a lobe is affected, so as to cause consolidation of a considerable area, the physical signs are pronounced; but when, as happens in a fair proportion of the cases, the collapsed patches are disseminated through both lungs and vary in size from a pea to a filbert, each consisting of one or more lobules separated by a network of normal cells, the physical signs are necessarily negative. However, the very absence of signs in the presence of decided lung symptoms will assist in the diagnosis. For example, if in the progress of a mild bronchitis, without corresponding increase in fever, grave symptoms suddenly arise,—the dyspnœa, lividity, and general distress being greatly aggravated,—and physical interrogation of the chest reveals no solidification of the lungs, the occurrence of lobular collapse offers the only satisfactory explanation of the sudden change.

When present, the physical signs are those of consolidated lung. The sonority of the chest is diminished over the affected spots, but the dulness has a marked tympanitic quality owing to the proximity of normal lung, and especially, as commonly occurs, if emphysematous patches surround the collapsed lobules. The normal breathing sounds are absent, and may be replaced by bronchial respiration and bronchophony. Vocal resonance is increased, and in acquired atelectasis abundant mucous râles are audible over the entire chest. A very important and characteristic feature of atelectasis is the suddenness with which the physical signs are changed. Occasionally, during an examination, dulness and bronchial breathing will be replaced by normal resonance and vesicular murmur; or within a brief period, abnormal sounds may appear and disappear in different portions of the lungs. This can happen in no other pulmonary disease, and depends upon the closing of the bronchi

plugs of mucus and their speedy removal by forced expiration in coughing, crying, etc.

DIAGNOSIS.—The recognition of congenital atelectasis, if extensive enough to give rise to symptoms, is comparatively easy. But the post-natal form is always associated with other morbid conditions which render the diagnosis difficult and sometimes impossible.

Capillary bronchitis, catarrhal pneumonia, and lobar pneumonia are the only diseases for which collapse is liable to be mistaken. Catarrhal pneumonia is rarely developed except in portions of the lung already collapsed, and hence cannot be differentiated by physical signs alone. Diffuse atelectasis differs from lobar pneumonia in the absence of fever, the percussion note is more tympanitic, bronchial respiration is less marked, and the crepitant râle is absent. The suddenness with which the physical signs are manifested and reach their full development in collapse is an important diagnostic point. If in the course of a bronchial catarrh symptoms of considerable severity suddenly supervene, such as rapid and shallow breathing, duskiness of the face, faint cough and feeble cry, with little or no increase in fever, the nature of the attack can scarcely be doubted. If along with these symptoms the physical evidence of solidified lung is present, the chain of evidence is complete.

The thermometer renders valuable aid in differentiating between the above diseases. Capillary bronchitis is normally attended with only moderate febrile movements, the mercury fluctuating between 101° F. and 103° F. A sudden exacerbation of fever in bronchitis, in which the thermometer registers 104° F. or higher, strongly suggests the onset of catarrhal pneumonia, on the other hand, a sudden fall of the mercury, without corresponding improvement in the symptoms, points strongly to collapse.

PROGNOSIS.—In congenital atelectasis, if restorative measures are adopted early and the lesion is not extensive, the prognosis is good. But if the child be premature or feeble, or if the fetal circulatory openings are unclosed, the outlook is bad in the extreme. The prognosis in acquired atelectasis is always grave; and if the condition occurs in whooping-cough, it is apt to be fatal. Convulsions are of bad omen. Lobular collapse is the initial lesion in many cases of catarrhal pneumonia, of which caseous degeneration and phthisis are not infrequent sequels. Emphysema, more or less extensive, is nearly always left behind, if any considerable tract of lung has been involved in the collapse.

TREATMENT.—The treatment consists in the adoption of measures and remedies to strengthen the respiratory process, to clear the air passages of all obstructions, and to sustain the strength. Artificial respiration by any of the recognized methods is of great importance in congenital cases. In crying and coughing, deep, full inspirations are instinctively taken, and hence these acts should be frequently provoked. Nothing conduces more strongly to perpetuate atelectasis than to indulge a feeble infant in a vegetative existence. Infants should not be permitted to sleep too long at one time, or to remain any great length of time in the same position. The body heat, often subnormal, should be carefully maintained by swathing the infant in cotton or flannel, and in extreme cases it may be kept for days or weeks in an incubator. In acquired or post-natal atelectasis remedies addressed to the bronchial catarrh, pleurisy, or other associated diseases are indicated and will be discussed in other columns of the HANDBOOK. It is only proper to remark here that those remedies should be chosen which, like the preparations of ammonium, increase the flow of serum and lessen the viscidity of the tough secretion which occludes the bronchioles. Opiates should be sparingly used. If not contraindicated by debility, emetics serve the twofold purpose of expelling viscid phlegm from the bronchial tubes and producing powerful inspirations. Those emetics only are admissible which act promptly and with little depression, as sulphate of copper and ipecac. Alcoholic stimulants are always indicated. Hot immersion baths, made more stimulating by the addition of mustard, and mildly irritating embrocations to the ch are useful. Nutritious diet and tonics, by which t respiratory muscles gain permanent volume and vig constitute our chief reliance, as soon as the immedia danger is tided over.

W. J. Conklin.

ATHEROMA. See *Blood-Vessels, Diseases of.*

ATHETOSIS (ἄθετος, without fixed position).—A cerebral affection characterized mainly by continuous, slow, deliberate motion of the fingers and toes, and by inability to retain them in any position in which they may be placed.

This new differentiation being now recognized by eminent pathologists both in English-speaking and continental countries, there is a deluge of reported cases of athetosis, many of which, however, are not strictly in accord with the definition; but the details in regard to the affection are well described, notwithstanding the objections of those who saw in athetosis nothing more than a complex symptom, or a variety of post-hemiplegic chorea.

SYMPTOMS.—The morbid movements of the fingers and toes, symptomatic of athetosis, are involuntary, grotesque, and complex in character, being of a more complicated form than those of simple flexion and extension. The contractions, which do not cease even during sleep, come on slowly with apparent deliberation and with great force. The fingers and toes assume various distorted positions, and carry out movements that would be nearly impossible in the normal state. There is a peculiar distorted position of the thumb and of the index finger, with sprawling abduction of the other fingers, which the hand constantly tends to assume in typical cases, and when once seen can never be mistaken. That which appears to be pathognomonic of athetosis is the localization and the peculiarity of the incessant complex involuntary movements of the smaller and more rapidly acting muscles of the limbs. They seem to prefer the peripheric ends of the extremities, such as the fingers and toes, and rarely the face. A gliding protrusion of the head is occasionally a characteristic of the disease, and in exceptional cases the morbid kinesis has extended to every voluntary muscle of the body. The patient is able to control these movements for a limited time by position and the exercise of an extreme effort of the will; but the disorder is increased by attempts at restraint, by exhaustion, cold, and emotion.

The essential feature of the disease seems to be an incoordination between the flexors and extensors of the muscles of the fingers and toes, in consequence of a lesion in the centre controlling the muscular movements of these members. It has been noted that the phenomena have partly the character of associated movements, for while the fingers moved, the arm was hard and rigid, and during the motion of the toes the muscles of the calf were in a state of tonic contraction. The muscles of the affected extremity are hypertrophied; but it often happens that the hand and foot affected may be atrophied. There is also vaso-motor disturbance in the affected extremity, which may be red, livid, moist, and colder than the corresponding extremity, and pain may also occur in the affected limbs. In some cases, the electric contractility of the muscles is enfeebled or it is increased; in others, it is normal. Relaxation of the ligaments and joints of the affected extremities has also been noted as a characteristic. The ankle clonus is frequently present.

The advent of athetosis is always sudden, and in most cases occurs in young children whose hereditary antecedents are bad, or in those who have suffered from an attack of convulsion and unconsciousness, or, what is more common, hemiplegia, a distinct attack of which in many cases precedes the appearance of the clonic spasm. It is often associated with epilepsy, idiocy, chronic hydrocephalus, and imbecility. Hammond says, however, that of the eight cases occurring in his experience, hemiplegia was not an antecedent condition in four. More recent authority is that athetosis is found in twenty per cent. of all cases of hemiplegia and infantile cerebral palsy. It has

also been observed in drunkards and occasionally in tabes and general paresis. Adults of irregular habits, between thirty and thirty-five years of age, are the occasional subjects of the affection. Two cases are reported to have occurred at the ages of forty-eight and fifty-seven respectively; and two others in consequence of sudden fright in girls of seven, both of whom had histories of hemicrania confined to the left side; and in another case the mother was exposed in pregnancy to violent psychical excitement. A case is reported to have followed infantile encephalitis. Another followed diphtheria, another a burn, and another a gunshot wound. It is not known that sex is an etiological factor, nor does the affection appear to be confined more to one side than to the other. In thirty-five cases it was confined to the right side in nineteen, and to the left in sixteen. When athetosis is confined to one side of the body it is designated as *unilateral* or *hemiathetosis*, and is symptomatic of disease of the cerebral centre.

Double or *bilateral* athetosis, which usually dates from infancy, is generally idiopathic and unaccompanied by hemiplegia; it occurs in cases in which there is probable atrophy of the brain. In fact, there seems to be a close relation between cerebral atrophy and this affection, the reason for which is not clear. A case is reported in which the spasms occurred in the right hand and the left foot. The muscles of the face and neck appear to be affected to a greater extent in this form than in the unilateral; there are no sensory disturbances; the reflexes are increased; the mental condition is variable; it may or may not be associated with idiocy, and the disorder is not necessarily post-hemiplegic.

Diagnosis.—Athetosis being a combination of symptoms somewhat resembling paralysis agitans, care should be taken not to confound it with that affection. A likeness to athetosis is also found in senile trembling, in the tremor characteristic of mercurial poisoning, and in that of disseminated sclerosis of the nerve centres. Other analogous conditions are the spastic contractions common after hemiplegia in children, and the movements that take place in chorea. Athetosis may be distinguished from all these by the peculiarity of the movements, which are slow, systematic, uniform, and apparently determinate. They have not the quick, jerky, unexpected character presented by other forms of clonic spasm, but are slower and of a gliding, quasi-rhythmical character that may be compared to the peristaltic action of some involuntary muscles, or to the movements in muscles affected by a peculiar form of cramp. The anomalous position of the hand, which is an exaggeration of that assumed by a baseball catcher, is an excellent diagnostic sign; slowness of speech and impairment of the intellect are also diagnostic aids. Electric excitability is increased in chorea; in athetosis it is normal.

Pathology.—Though the pathological anatomy of the affection may not be stated in such clear terms as its clinical phenomena, yet the cases seem to warrant the act of making a distinct pathological entity of athetosis and the placing of it in the category of brain diseases. The pathological characteristics appear to be degenerative changes in the corpus striatum and the optic thalamus. In one recorded case the disease was thought to be caused by an embolus blocking the middle cerebral artery; and the post-mortem examination showed the disease to be limited to the optic thalamus, the corpus striatum, and the parts just external, thus justifying Dr. Hammond's original surmise as to the probable seat of the affection, before he had as yet had an opportunity to ascertain by necropsy the nature of the lesion that causes the symptoms. The true nature of this class of cases, however, awaits further pathological evidence. Later observers think that the clinical manifestations of athetosis are owing to functional disturbances or obliquity in the motor centres rather than to any recognizable structural change.

Treatment.—So far but few cases of athetosis have recovered. Slight cases may do so approximately. Sedatives and nerve tonics and the application of galvanism are recommended. The chloride of barium, arsenic, ergot, and cannabis indica have all been given with indifferent results. On the one hand, it is reported that marked improvement follows the application of the constant current; on the other, that both galvanization and faradization lead to no results. It would probably be well for the patient to exercise the fingers by a graduated system of lifting in conjunction with vigorous efforts of the will.

Irving C. Rosse.

For more detailed and systematic information, with copious bibliographical references, the reader may consult Seeligmüller: "Ueber Athetose," Schmidt's Jahrbücher, Leipzig, 1881; Michailovski, Dimitri; Ivani: "Etude clinique sur l'athetose double," Paris, 1892; also current numbers of Giornale di Neuropatologia, Napoli.

ATLANTIC CITY.—New Jersey. This, a much-frequented resort for invalids, is situated on the coast of New Jersey, fifty-seven miles southeast from Philadelphia. It is connected with the latter city by three lines of railroad, one of these being a branch of the Philadelphia and Reading Railroad and the other two forming a part of the Pennsylvania Railroad system, by means of which it is placed in direct connection with New York and New England, as well as with the West and South. One of the lines of the latter company now crosses the Delaware River above Philadelphia by a bridge, so that the former inconvenience of ferriage, in going to Atlantic City from western and southern points, may be avoided.

Atlantic City is in latitude 39° 22′, and could at one time be properly described as situated at a point on the upper part of Absecom Beach, an island ten miles long and averaging about half a mile wide; but with its suburbs of Chelsea, Ventnor, South Atlantic City, and Longport (the first two of which have become practically continuations of the main resort), it now really includes the entire island, though there are still considerable gaps of unoccupied beach in its lower part. A trolley line extends from one end of the island to the other, thus closely connecting the various suburbs with Atlantic City proper.

Absecom Beach has a very dry, porous, sandy soil and is separated by a narrow arm of the sea from the mainland of South Jersey. Almost this entire region, which includes Lakewood, Hammonton, Vineland, and other towns of greater or less importance, has become famed for the salubrity of its climate, the sandy barrens covered in places with pine forests having a dryer air than is usually found at the same proximity to the sea. The fact that the winds from the west, northwest, and north must pass for many miles over this sandy region has doubtless something to do with the peculiar quality of the air observed by most visitors to Atlantic City, especially its dryness when the wind is from the landward.

The writer, who practised for twenty years in Atlantic City, deems it right to record here as the result of his own observation the fact that the air there is nearly always tonic and invigorating from whatever quarter the wind may blow, but that directly on the beach or ocean front it is comparatively moist when there is a sea breeze, as must be the case, of course, at all seaside localities. As to asthma, there is no uniformity in the influence of the climate. Many cases of it are aggravated there decidedly, but nearly an equal number of those seen by the writer experienced benefit. It would be unwise for any asthmatic patient to arrange for a long stay at Atlantic City until after testing the climate by sojourning there a night or two. While some were glad to escape after passing a single night of distress, others, who always suffered severely elsewhere, sojourned for considerable periods there, and in some instances an entire winter, without an attack.

With regard to patients affected with pulmonary phthisis, the more populous parts of the town are not so well suited to them as the newer suburbs below. During his residence there the writer was accustomed frequently to see cases of early phthisis progress favorably in Atlantic City, but those in the second and third stages did not often do well unless in a very stationary condition,

when the stimulating character of the air sometimes seemed to effect improvement even in them.

In rheumatism and neuralgia, as with asthma, the effects were various. Some cases were aggravated, especially when the sufferers while at the shore followed their accustomed self-indulgent habits of eating and drinking with little or no exercise. Others who had learned to live hygienically and did not indulge too far the enormous appetite which the sea air usually produces, often gained decidedly in health. In insomnia there was in most cases a marked improvement, and many who had required hypnotics at home slept well in Atlantic City without them, especially when such drugs were stopped at once upon their arrival. But patients with bad livers, stomachs, or bowels who could not be made to follow proper dietetic rules, and those especially who were under a stimulating regimen as to both medicines and diet, found that they were no better able to dispense with appropriate treatment there than in any other place, while suffering from an excessive proportion of hydrochloric acid in their gastric juice. But, for the most part, the victims of neurasthenia responded in an astonishing way to the tonic and restorative influence of the climate, and all the more so, usually, when they had in addition to the air sea-water baths in just the right doses, though in summer invalids who attempted to bathe in the surf without medical advice nearly always overdid it sooner or later, and thus often lost more than they gained.

Disinterested testimony as to what a certain climate has done for various classes of invalids ought to be more useful than the meteorological statistics from which we often endeavor vainly to gain some definite idea concerning its desirability and efficacy as a curative agent; and a large mass of such testimony is available with regard to the effects of the climate of Atlantic City; but lack of space prevents its use here. In articles like this, however, it is necessary to furnish at least a few statistics, and accordingly we reproduce below some facts and figures coming from the Weather Bureau and the office of the United States Coast and Geodetic Survey.

These official sources of information were freely drawn upon by the writer in preparing a paper some years ago on the climate of Atlantic City.* In describing then the course of the Gulf Stream, he said:

"This really includes numerous parallel or slightly diverging currents of very warm water with overflow currents of a somewhat lower temperature. One of these overflow currents approaches within sixty-five miles of Atlantic City, while it is one hundred and ten miles from Sandy Hook. The principal current is farther away, being one hundred and thirty-five miles from Atlantic City, one hundred and eighty-five miles from Sandy Hook, and about the same distance from Long Branch and Montauk Point.

"But the exceptional mildness of this climate may be attributed to the peculiar course of the Gulf Stream in this vicinity as much as to its proximity. The innermost current, according to the map received from the Coast Survey Office, has a direction opposite Atlantic City of east-northeast, but turns more and more to the eastward till in latitude 40°—that of Philadelphia—it bears nearly due east. The main current turns more abruptly, and a little north of latitude 38°, some distance to the southward of Atlantic City, has a course directly eastward. Our south, southeast, and east winds, then, must all pass for three hundred to five hundred miles at least over more or less heated water which has come directly from the Gulf of Mexico. Our only ocean breezes not affected in this way are those from the northeast."

While the coast of New Jersey has a general trend from northeast to southwest, the beach in front of Atlantic City makes a sharp turn to the westward, so that it faces almost directly southward. South as well as east winds and even south-southwest winds are, therefore, sea breezes there and blow off the Gulf Stream. This southern exposure enjoyed by the town is, climatically, a decided advantage which is possessed by no other part of the New Jersey coast except its southernmost extremity at Cape May. In the article on Atlantic City, which appeared in the first edition of this work, occur the subjoined paragraphs, written by Dr. Huntingdon Richards, a distinguished authority on climatology:

"In the absence of shelter from the winds, it is consoling to reflect that their force and frequency at Atlantic City are less, in all probability, than at any other well-known place of resort lying upon the New Jersey coast. In a table showing the average yearly movement of the atmosphere for the five years, 1880 to 1884, inclusive, the following figures stand opposite the four stations, Atlantic City, Barnegat, Cape May, and Sandy Hook: Atlantic City, 82.630; Barnegat, 122.988; Cape May, 130.055; Sandy Hook, 118.450. The figures of this table (quoted from "Atlantic City as a Winter Resort," by B. A. Blundon, Sergeant, Signal Service, U. S. A.) reveal the fact that, during the five years above mentioned, the average amount of wind blowing at Atlantic City was 31 per cent. less than at Sandy Hook, 33 per cent. less than at Barnegat, and 37 per cent. less than at Cape May. Concerning the relative frequency of winds blowing from the different points of the compass at Atlantic City, a table giving the result of observations made during the three years intervening between July, 1876, and July, 1879, shows that 9 per cent. of such winds were from the north, 11.7 per cent. were from the northeast, 15.3 per cent. were from the northwest, 16.1 per cent. were from the west, 8.3 per cent. were from the east, 6.3 per cent. were from the southeast, 15.9 per cent. were from the southwest, and 17.4 per cent. were from the south.

"During the warmer part of the year Atlantic City, and all other places lying upon the New Jersey coast, are visited daily (with but rare exceptions) by a delightful sea breeze, which begins to blow at about eleven or twelve o'clock in the day, and lasts until nightfall. . . .

"A particularly striking feature in the climate of Atlantic City is the comparatively small amount of the annual rainfall. A table on page 11 of the pamphlet entitled, 'Atlantic City as a Winter Resort,' shows that the rainfall is less in amount at Atlantic City than at any other point on the Atlantic coast of the United States, with the single exception of Portland, Me.; and that it is fully twenty per cent. less than at the neighboring station of Barnegat—a singular fact, and one very difficult of explanation."

It should be mentioned that while, like Brighton, England, Atlantic City is an all-the-year-resort, and a considerable amount of business is done by many of the hotels and boarding-houses even in the dullest months, yet the season—that is, the rush of visitors—may be said to begin in February and the crowds dwindle rapidly in September. The autumn months, when the place is the least frequented, are really the most desirable of all for invalids, the sea breezes being then deliciously balmy.

While a resident in Atlantic City, the writer made careful and regular observations of the weather during the winter of 1879–80. These showed that in December, 1879, there were twenty-six days during which the thermometer did not fall below 32° F.—the freezing point; also that there were only two days in the same month when the thermometer did not indicate at noon a temperature above 40° F.; and that there were ten days upon which it was not below 50° F. at the same hour. During the January following (1880) there were twenty-four days during which the mercury never fell below the freezing point at any hour, and only two days during which it went below 30° F. It was only once in the same month lower than 40° F. at noon, and only three times lower than 45° F. at the same hour. On nineteen of the thirty-one days the thermometer stood at 50° F. or above at midday.

* **Winter Health Resorts.** "The Climate of Atlantic City and Its Effects on Pulmonary Diseases," Philadelphia Medical Times, December 18, 1880.

CLIMATE OF ATLANTIC CITY, N. J., LATITUDE 39° 22′; LONGITUDE 74° 25′. CONDENSED FROM A CLIMATIC CHART OF TEN YEARS, IN THE PREVIOUS EDITION OF THIS HANDBOOK, AND FROM UNITED STATES WEATHER BUREAU OBSERVATIONS FROM 1891 TO 1898, EXCEPTING THE YEARS 1895 AND 1896.

Data.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Average for nine months.
Temperature—Average or normal	34.2°	39.0°	46.9°	57.2°	66.7°	71.6°	72.3°	69.3°	56.7°	56.9°
Average daily range	14.8	14.1	13.7	12.7	14.0	13.6	12.2	12.6	12.9	
Mean of warmest	42.4	45.5	53.5	63.9	74.5	79.9	77.4	74.8	64.3	
Mean of coldest	27.6	31.4	39.8	51.2	60.5	66.3	65.2	62.2	51.4	
Highest or maximum	65.3	67.5	75.8	84.1	91.8	93.5	89.5	89.7	81.2	
Lowest or minimum	2.7	13.6	23.6	37.3	47.0	54.4	55.3	45.0	31.6	Total precipitation for nine months.
Humidity—Average relative	79.5%	79.5%	78.1%	81.1%	82.6%	83.6%	82.8%	80.7%	79%	
Precipitation—Average in inches	3.06	3.96	3.59	2.35	2.32	2.99	5.23	3.82	2.80	30.12
Wind—Prevailing direction	N. W.	N. W.	N. W.	S.	S.	S.	S.	S.	W.	S.
Average hourly velocity in miles	10.8	12.0	11.7	10.1	8.7	7.7	9.0	10.4	9.6	10.
										Total for nine months.
Weather—Average number clear days	6.6	9.5	12.3	10.8	12.3	10.5	13.5	13.0	11.8	100 3
Average number fair days	7.5	9.0	10.6	9.6	12.8	13.6	11.0	10.3	9.3	93.7
Average number clear and fair days	14.1	18.5	22.9	20.4	25.1	24.1	24.5	23.3	21.1	194.0

From the records from which these climatic statistics have been compiled, it is learned further that in 1891, during the nine months of the season from February 1 to November 1, the mercury fell to 32° F. only twice in February and three times in March, and that it did not rise above 90° F. except once, which was in July, when it reached 91° F. In 1892, during the same period, it fell below 32° F. four times in February and three times in March. It rose above 90° F. once only, which was in July.

In 1893 it was below 32° on seven days (which included the nights as well) during the period of nine months—five times in February and twice in March. It exceeded 90° F. once only in that year, reaching 93° F. on one day in July. In 1894 it was below 32° F. on six days and nights in February only, and did not rise above 90° F. even once during that year.

Meteorologically speaking, one of the important advantages of Atlantic City as a winter and spring resort is the small amount of snow there in comparison with other localities in the same latitude and with most places in the Northern and Middle States. This is much more striking than even the figures of the Weather Bureau would lead one to infer, for the reason that in consequence of both the porous sandy soil and the effects of the strong sea air, most of the snow that does fall there is melted almost immediately or within a day or two. It is, as a rule, only in the very exceptionally severe winters that sleighing may be enjoyed for a week or two, and even then usually early in the winter before the season has fully opened. A handsome ocean promenade forty feet wide, elevated twelve feet above the beach on steel supports, and known as the board walk, skirts the front of the town and its nearby suburbs for five miles, and on this snow is never allowed to lie, even when it lingers longer than usual elsewhere, so that the throngs of invalids on foot or in wheeled chairs may always be able to enjoy an outing under comfortable and cheerful conditions. During the busy season these throngs of health-seekers pass continually to and fro with the ever-attractive breakers rolling in on the one side (at some points even under their feet), the sun shining down in full force from above as well as reflected from the water so as to have double power, and the continuous buildings on the landward side affording an efficient shelter from the winter winds which blow from the north or west when cold enough to be annoying. This board walk, extending for miles along the edge of the water, is the chief attraction of Atlantic City in all seasons of the year, but in winter it is of marked advantage to invalids in enabling them to spend most of their time in the open air and sun, except in the worst weather. When it actually storms, invalids may sit in the comfortable sun parlors or glass-enclosed porches connected with a large proportion of the nine hundred hotels and boarding-houses which Atlantic City now possesses, and a part of which are open all the year. The board walk and omni present sun parlor are two almost unique features of this popular resort.

There is an abundant supply of pure water drawn mainly from springs and creeks on the mainland, but also in part from a number of deep artesian wells. Underground sewers, deeply placed according to a novel system, convey the sewage to a central point on the meadow back of the town, where it is pumped to a sufficient elevation to admit of its flowing by gravity to the waters of the bay so far away from the hotels and residences, as well as from the bathing grounds, that it never causes the slightest offence or inconvenience.

The population of Atlantic City is now about 30,000, and it may be interesting to add that besides the nine hundred houses that entertain guests, including a number of first-class hotels with all the modern conveniences, there are in the town twenty-six churches, a casino, a number of good theatres, and numerous minor places of amusement (the number of such in the height of the summer season having been estimated as high as two hundred), three daily papers and five weeklies. Sixty-five physicians of all kinds, including some unusually able men, look after the needs of the sick and ailing, while twenty-eight drug stores see to it that no one suffers for lack of medicines. There are also a fully equipped hospital and several well-managed hot-and-cold sea-water bathing establishments. The Atlantic City Country Club with golf links affords recreation for guests in the spring and summer, and there are also abundant facilities for rowing, sailing, and fishing in the waters all around.

A fine level driveway near the beach from Atlantic City to Longport at the lower end of the island is much appreciated by coaching parties as well as by bicyclists. In short, very few if any health resorts even in Europe offer a larger total of advantages or a greater variety of ways in which invalids may agreeably pass the time while wooing back their lost health.

Boardman Reed.

ATOTONILCO.—Municipality of Chiconcuautla, Puebla, Mexico. This spring is located near the town of Tlaltenango. According to an examination made by Zuñiga the water has a sulphurous odor, is slightly unctuous to the touch, limpid in appearance, and contains the carbonates of lime and magnesia, sulphurous acid, and carbonic acid and sulphuretted hydrogen gases. It is recommended in rheumatism, neuralgia, and diseases of the skin.

N. J. Ponce de Léon.

ATOTONILCO DE SAN ANDRES.—Municipality of San Andres, Zacatecas, Mexico. The waters of these springs are lukewarm and contain sodium sulphate and other ingredients. They are recommended for syphilis and skin diseases, but no bathing facilities have been provided.

N. J. Ponce de Léon.

ATRESIA.—(Imperforation, closure, or absence of a natural opening or passage.) There may exist an atresia of any one of the external orifices or internal passages of the body: Atresia pupillæ, A. palpebrarum, A. oris, A. auris, A. tracheæ, A. œsophagi, A. bronchii, A. intestini, A. recti, A. ani, A. vaginæ, A. urethræ, A. vesicæ, A. uteri. The imperforation may be the result of disturbances of development in fetal life, or it may arise secondarily to local inflammatory processes either before or after birth, or may be produced by mechanical obstruction, pressure, etc. According to the etiology we may therefore distinguish two classes of atresia, the congenital and the acquired.

Atresia Pupillæ.—Congenital closure of the pupil of the eye not infrequently occurs, and is usually the result of a persistence of the pupillary membrane which in fetal life covers the lens and as a rule disappears in the last month of pregnancy. Various forms of this malformation occur: the pupil may be entirely covered by a thick grayish membrane containing blood-vessels, or by a network of fine threads in which vessels run, or irregular brown or grayish patches may appear in the pupil. Acquired atresia of the pupil is of rather frequent occurrence in adult life as the result of inflammations of the iris and choroid, but it may take place at any time, even before birth. In chronic iritis the pupil may be partially or completely closed by vascular connective tissue.

A. Palpebrarum.—Total imperforation of the eyelids is not of frequent occurrence. The congenital form is usually associated with grave defects of development which do not permit of extra-uterine life. The edges of the lids may be firmly adherent to each other and to the eyeball (symblepharon). The condition may be caused by a failure of separation of the conjunctivæ, intra-uterine inflammations of the eye, or it may be caused by amniotic adhesions. The latter cause is probably the most frequent. One or both eyes may be affected. Remains of the amniotic adhesions may be found in the shape of tags, bands, or firm membranes covering the lids and adherent to them. Acquired atresia of the eyelids (symblepharon, ankyloblepharon) occurs after severe ulcerations, diphtheritic conjunctivitis, burns caused by lime, hot metal, and explosives. In cases in which there is complete occlusion the edges of the lids are firmly united to each other and to the eyeball.

A. Narium.—Complete atresia of the nostrils is rare and is usually found in association with cyclopia. In this type of monster the nostrils are represented by one or two fleshy imperforate tags which are usually placed in the forehead above the solitary eye. The atresia of one nostril through a congenital obliquity of the septum is not infrequent, and is of great practical importance because of the habit of mouth-breathing and the chronic catarrhs of nose and pharynx which are associated with it. Acquired stenoses of one or both nostrils are also not rare. The closure may be caused by new growths, polypi, injuries, chronic catarrhal conditions, etc. This condition is likewise of great practical importance.

A. Oris.—Complete absence of the mouth is a very rare occurrence, and is always associated with marked defective development of the head and face. It is most frequently the result of amniotic adhesions, or of an abnormal tightness of the cephalic cap of the amnion. Partial atresia (microstomia) is of more frequent occurrence, but is rarely found in a viable fœtus. Congenital closure of the fauces is likewise of rare occurrence.

A. Auris.—Complete failure of development of the external auditory meatus occurs very rarely. The lumen of the meatus may be filled with compact bone or cartilage, or it may be closed by a firm membrane of connective tissue in which small islands of bone or cartilage may be present. With this malformation there is almost always associated a defective development or entire absence of the external ear, and imperfect development of the tympanum and internal ear. The site of the ear may be indicated only by a slight indentation. In other cases a cartilaginous canal may be present which is closed at a slight depth by bone or membrane. Partial atresias, hour-glass or symmetrical narrowing of the external canal, are of rather frequent occurrence. In these cases the external ear may be normally developed or show greater or less malformation.

Acquired atresia of the external canal is not rare. Inflammations may cause thickenings of the wall of the meatus, and stenosis or constriction may result from the formation of connective tissue. Very frequently there is a polypoid growth of granulation tissue into the canal, and through the adhesion of the granulating surfaces complete atresia of the canal may result; or bands, bridges, and septa of connective tissue may be formed. A subperiosteal formation of new bone may lead to osseous atresia; in other cases exostoses may block the canal. Detached osteomata sometimes develop in the granulation tissue formed in inflammatory processes. Further, cholesteatomata are rather frequently found blocking up the external canal. In these cases all parts of the ear may be perfectly developed and the tympanum intact. It is therefore probable that these formations owe their origin to a desquamative inflammation of the lining of the canal. In very rare instances they may develop from epidermoidal cells which during the period of embryonic life have found their way into the meatus. Plugs of cerumen, foreign bodies, tumors, parasitic growths, etc., may also lead to an acquired atresia of the auditory canal.

A. Tracheæ, Bronchii, etc.—Atresia of the larynx through the formation of connective-tissue membranes or through the adhesion of the walls is of very rare occurrence, and has been observed only in cases showing marked malformations of the face. There may be complete absence of the trachea, the bronchi being given off directly from the larynx. In other cases the trachea may be represented by a fibrous cord-like structure, or its walls may be united by the formation of connective tissue. Similar formations of connective tissue may block the main bronchi, the trachea ending in a blind tube. Partial narrowing of the respiratory passages is not uncommon. The acquired forms of stenosis of the trachea and bronchi are for the greater part produced by conditions external to these structures, new growths in the neighboring lymph glands, aneurisms, etc. Obstruction of the passages themselves may be produced by inflammatory conditions, foreign bodies, etc. New growths within them are of rare occurrence.

A. Œsophagi.—Atresia of the œsophagus throughout its entire length is very rare. Congenital imperforation of this organ is most frequently found in the lower two-thirds, the upper third being open and ending in a blind tube, while the lower closed portion is represented by a thin cord-like structure. Associated with the congenital atresia there is almost always an abnormal communication with the trachea either at the lower end of the upper portion or at the upper end of the lower portion, which may be continued as an open canal from the point of communication. In other cases the middle portion of the œsophagus may be obliterated, so that the upper and lower portions are separated from each other by an imperforate cord of connective tissue. In these cases no connection with the trachea may exist. As a rule this form occurs late in fetal life and is most probably due to inflammatory processes. Acquired stenoses of the œsophagus are of relatively frequent occurrence and are of great clinical importance. They may be caused by pressure of tumors in the cervical or mediastinal lymph glands and thyroid, by mediastinal tumors, aneurisms, etc. The lumen may be obturated by polypoid growths of the mucosa, carcinoma, thrush, foreign bodies, etc. Strictures are produced by contractions of scars resulting from the effects of alkalies, acids, carcinomatous and syphilitic ulcerations, etc.

Complete occlusion of the stomach is very rare. Occasionally the organ is very small, resembling a portion of the intestine. Congenital occlusion of the pylorus is very rare, while acquired stenosis at this point is relatively frequent. In almost every case the latter is due to the obstruction or constriction of the orifice by new

growths, but it may be caused by healing ulcers or by pressure from without. Partial constriction of the stomach may occur in any part of the organ through the contraction of healing ulcers, new growths, etc. (hour-glass constriction).

A. Intestini.—Congenital atresia or stenosis may occur at any portion of the intestinal tract. There is usually only a single such closure, but occasionally multiple atresias may be found. The intestine may be entirely absent for a portion of its course, or be represented by a cord-like band of connective tissue. The portion of mesentery belonging to the obliterated intestine is also absent. The entire jejunum and ileum may be absent, the duodenum ending in a blind sac. In such cases both stomach and duodenum may be greatly dilated. The most common site of intestinal atresia is in the region of the opening of the ductus choledochus. If it is below the opening the collection of secretions together with the swallowed amniotic fluid may cause an extreme dilatation of the duodenum and stomach. The lower portion below the imperforation begins in a blind sac. In other cases the atresia is located above the opening of the common duct, so that bile passes into the lower portion of the intestine, as shown by the presence of meconium. The genesis of the larger congenital defects of the intestine has not yet been satisfactorily explained. Peritoneal adhesions, embolic infarction of the mesentery, etc., have been thought to be primary causes, but no conclusive evidence has yet been shown. It is more probable that some essential defect of development, such as an abnormal axis rotation, lies behind these malformations. The smaller localized atresias occurring in late fetal life are most probably the result of pathological processes in the peritoneum, and in some cases this has been definitely shown. Such conditions are most frequently found in children with congenital syphilis who die a few days after birth. Acquired obliteration of the lumen of the intestines is not uncommon, the most frequent causes being new growths, constriction of healing ulcers, peritoneal bands and adhesions, etc. They may be found in any portion, but are more common in the large intestine, particularly in the region of the sigmoid flexure and rectum.

A. Ani.—Of all the congenital atresias the most common and important is that of the rectum and anus. According to the location of the imperforation a number of varieties of this malformation exist, the most important of which are:

(*a*) *A. Ani Simplex.*—In this form the anus is closed by a connective-tissue septum of varying thickness. It may be a very thin membrane so that the contents of the rectum may be easily felt through it, or the rectum may end in a blind sac some distance above the anus. In other cases the free end of the rectum lies in the pelvis and is usually greatly dilated. This malformation is not always a primary defect of development, but may be caused by an abnormal growth of connective tissue. In other cases there may be a complete failure of development of the lower end of the intestine. In place of the anus there is usually only a slight depression in the skin. The sphincter is usually formed.

(*b*) *A. Ani et Recti.*—The large intestine may end in a blind sac far above the anus, which is usually not indicated at all, or only by a very slight groove in the skin.

(*c*) *A. Recti.*—The anus may be perfectly formed, but the rectum fails entirely or is converted into a solid strand of connective tissue.

In these forms the sinus urogenitalis may be normally developed, or the original communications between the intestine and the anterior portion of the cloaca may remain preserved, or the rectum may open into the perineum anteriorly to the anus, or into the scrotum, penis, bladder, vagina, uterus, or urethra. We may, therefore, further distinguish such forms as, *atresia ani vesicalis*, atresia of the anus with fistula of the bladder; *atresia ani urethralis*, atresia of the anus with opening into the urethra—usually the membranous portion, as this malformation is found almost exclusively in male individuals; *atresia ani vulvo-vaginalis* and *uterina*, atresia of the anus with communication of the rectum into the vagina, vulva, or uterus. In other forms both the rectum and the sinus urogenitalis may open into a common closed space which has no external opening and which through the collection of urine and meconium may become greatly dilated. The more marked malformations of this class preclude life, but some of the cases are capable of surgical cure. Acquired atresias of the anus or rectum are not infrequent and are produced by new growths, cicatricial contraction of healing ulcers, syphilitic processes, etc.

A. Urethræ et Vesicæ.—Total atresia of the male urethra occurs rarely, and is found in association with complete absence of the external genitals. As a result of the collection of urine in the bladder an enormous dilatation of the abdomen may occur which may be so great as to prevent normal delivery. Rauber observed an adult male with complete absence of penis whose urethra communicated with the rectum. The most frequent localized atresia of the male urethra is at the external meatus and orifice of the prepuce. Imperforation of the anterior urethra occurs rarely as a result of defective development of the urethral septum, and in the posterior portion as a result of proliferations and adhesions. Congenital atresia of the female urethra also occurs rarely, and may affect the entire length of the urethra or only a portion. As a result of the congenital imperforation of the urethra in both sexes, congenital dilatation of the bladder, ureters, and pelvis of the kidneys results from the retention of urine. Occasionally the urachus remains open and there is an escape of urine from the umbilicus, or there may be abnormal communications with the intestines, vagina, uterus, etc., by which the urine passes. Acquired atresia of any portion of the urinary passages may occur as the result of cicatricial adhesions and contractions, new growths, tuberculosis, syphilis, external pressure, etc. Gonorrhœa and direct injury are the most common of these factors.

A. Vaginæ et Uteri.—A congenital total atresia of the female genital tract may exist in connection with a total defect of the external genitals. The vagina may end in a closed space in common with the bladder and rectum (persistence of the cloaca). The most common site of congenital atresia of this tract is at the opening of the vagina, which is closed by a membrane of greater or less thickness (gynatresia). The imperforation may be due to an abnormally thick hymen (atresia vaginalis hymenalis). The closure may extend throughout the entire length of the vagina or occur at any portion. Complete absence of the vagina is rare, more frequently the organ is represented by a fibrous cord. The closure is due to a failure of the epithelial layers to separate or to secondary adhesions. Congenital atresia of the uterus is also rare. The occlusion occurs usually at the cervix, which may be closed partly by mucosa or partly by muscle and connective tissue. This condition may exist without other malformations and remain undiscovered until puberty, when the collection of the menstrual discharges within the dilated uterus and tubes may give rise to very important symptoms. The atresias of the vagina may similarly assert themselves. Complete absence of the tubes occurs in connection with marked malformations of the uterus. Atresia of either the abdominal or uterine end may occur, or an imperforation may exist in any part of the tube.

Acquired atresias of the female genital tract may be the result of cicatricial contractions following ulcerations, etc. (gangrenous vaginitis, tears, use of caustics, cervical amputations, retained pessary, tumors, etc.). The majority of the atresias of the vagina and uterus which are not associated with marked malformations are amenable to surgical treatment. *Aldred Scott Warthin.*

ATROPHIA PILORUM PROPRIA.—By this term is meant simple atrophy of the hair uncomplicated with apparent disease of the scalp. Under it are included at least three forms, namely: fragilitas crinium, trichorrhexis nodosa, and monilethrix. They have one feature

in common, which is that the hairs are friable, splitting or breaking with slight traction.

Fragilitas crinium.—This is also called **scissura pilorum.** The characteristic of this disease is that the hair is dry and splits either at its ends or in its continuity. It may be symptomatic or idiopathic.

1. *Symptomatic Fragilitas Crinium.*—This is a very common affection of the hair, and is met with in many diseases of the scalp, such as eczema, ringworm, favus, and seborrhœa. Whenever the scalp is abnormally dry, and also in general constitutional diseases in which the nutrition of the body is lowered, the hair may become dry and split. It is seen chiefly in the long hair of women. If the hair is viewed in mass it looks as if it had been singed, if the case is a severe one. In any case, if the hair is held in the hand in a good light it will be noticed that the ends of the hair are split into several diverging filaments.

2. *Idiopathic Fragilitas Crinium.*—In this form, which is much rarer than the preceding, the hair splits at the end without any apparent disease of the scalp. The split may be at the free end, in the continuity of the shaft, or within the bulb. The hair may be cleft only at the end, or the cleft may run up the shaft for a variable distance. If the cleft occurs in the continuity of the shaft the filaments may hold together or separate widely. The disease is seen most often in the long scalp hair of women. It occurs also in the beard. There may be but a few hairs affected or there may be many, giving the singed appearance spoken of above. In some cases, as the hair splits and breaks off before it has attained any great length, the woman is unable to put up her hair, and has to wear it cut short.

Fig. 378.—Trichorrhexis Nodosa.

Pathology.—Usually, nothing further abnormal is found about the hair than that it splits. The hair bulbs may be normal or atrophied.

Etiology.—We do not know what the cause of the disease is. We assume that it is a disturbance of nutrition. In very long scalp hair it may be due simply to a lack of nutrition on account of the length of the hair.

Treatment.—The split hairs should be cut off above the cleft. Every effort must be made to improve the nutrition of the patient, and to cure any disease of the scalp. A little oil, vaseline, or pomade should be rubbed into the scalp several times a week. In massage we have the best stimulant, when properly done.

Trichorrhexis Nodosa.—Also called clastothrix, and nodositas crinium. This is a disease of the hair characterized by the appearance along its shaft of one or more nodose swellings, and by the breaking of the hair through the nodes.

Symptoms.—The disease affects most often the hair of the beard. The patient notices, when handling the beard, that there are irregularities upon some of the hairs; or else he sees that his beard looks ragged. On examining the hair there will be found one or more whitish, gray, or normal colored, shiny, transparent, nodular swellings, not unlike the nits of pediculi, excepting that they are oval and involve the whole circumference of the hair, not pear-shaped and fixed on one side of the hair as in pediculosis. There have been found as many as five nodes on one hair. The diameter of the nodes varies with the diameter of the hair. The nodes are usually on the upper third of the hair. The hair is very brittle and easily broken by combing it or by handling it, or the break may occur seemingly spontaneously. The fracture takes place almost invariably through the node. When the hair breaks completely the remaining end will have a frayed-out appearance. If the ends do not separate, but the break is through the node, then the appearance will be that of two small paint brushes pressed end to end. The fracture may be longitudinal through the node. When many hairs are affected we see the same singed appearance met with in fragilitas crinium.

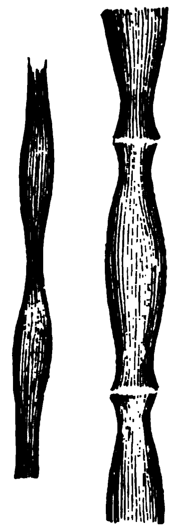


Fig. 379.—Monilethrix.

While the disease was first described as affecting the beard, it is seen also on the scalp hair, especially in women. The scalp hair being so much finer than is the hair of the beard, the nodes are very much smaller and more apt to be overlooked. Sometimes the nodes on the scalp hair are found only with the microscope. The disease has also been met with on the pubic hair, the scrotal hair, and the hair of the labia majora, the axillæ, and the eyebrows.

Etiology.—The cause of the disease has not been determined. It may be a disturbance of the nutrition of the hair. By some it is thought to be a neurosis. McCall Anderson has reported a case in which the disease seemed to be hereditary. In some countries, as about Constantinople, it is far more prevalent in the scalp than in other countries. By some investigators parasites are believed to be the cause of the disease, and a microorganism is said to have been found. Others deny the presence of a microorganism. Simple handling of the beard has also been credited with producing the disease.

Treatment.—Thus far treatment has been most unsatisfactory. Mercurial ointments may be tried. Gamberini recommends bathing with a lotion of three drachms of subcarbonate of potassium in four ounces of distilled water; or using inunctions of tannic acid or oil of cade. Schwimmer advises an ointment of seven grains of oxide of zinc, fifteen grains of washed sulphur, and two drachms and a half of simple ointment. This is to be rubbed in night and morning. As far as the beard is concerned the chief reliance is upon shaving, with the hope that after a time the hair will grow in properly.

Monilethrix.—This is also called **aplasia pilorum propria.**

Symptoms.—This form of atrophy of the hair is often mistaken for trichorrhexis nodosa, because like it it is marked by the presence of nodes on the hair. It differs from it in that the nodes are the normal parts of the hair, and in that the fracture in it takes place through the internodular part.

In the vast majority of cases the disease is congenital, though it may come on late in life. The subjects are therefore usually infants. They are commonly born with normal appearing hair, but after a few weeks the hair breaks off from the whole head or from patches, giving a stubbly appearance to the hair, similar to what is seen in ringworm. In some cases the scalp is reddened and has on it a number of small, scaly, elevated cones, or perhaps pustules. From the little cones protrude short, stubby hairs. Many of them are bent, and all break easily on slight traction. They are seldom longer than a quarter of an inch, and often are no more than black points. By the naked eye, or under the microscope, these little hairs show fusiform swellings with contractures between, through which the fracture has occurred. Sometimes complete baldness results. All the hairy regions may be affected. A general keratosis pilaris may be present.

Pathology.—Under the microscope the hairs will be

found to have on them, at regular intervals, alternate swellings and constrictions. The swellings, or nodes, are about 1 mm. long, fusiform in shape, and darker in color than the constricted parts. The latter are about one-third the length and diameter of the nodes. The constricted parts contain neither medulla nor pigment and may consist of the cuticular layer of the hair alone. There is atrophy of the hair bulbs. The nodes are all along the hair from the root to the point. Fracture invariably takes place through the internodular portion, and frayed-out ends may be found. Sabouraud found that the constrictions formed at two days' interval. Gilchrist believes that the disease originates in the hair follicle very near to the papilla. He was able to trace the fusiform swelling to the lower fourth of the hair shaft, where there were constrictions in the walls of the hair follicle. He found no change in the hair papillæ.

Etiology.—In many cases the disease is hereditary. Several observers have reported instances of a number of cases in the same family. At times it shows a tendency to descend in the same sex, a peculiarity shown in other dermatoses. It is probably a trophoneurosis.

Treatment has thus far been without effect. Stimulation might be tried, but the prognosis is bad.

Besides these well-defined forms of atrophy of the hair we have reports of allied diseases from single observers. Thus Crocker describes a case of *end atrophy* of the hair in which the distal ends of the hairs are bulbous and of lighter shade than the rest of the hair.

PHAGMESIS is another abnormality of the hair in which feathers instead of hair are met with. This is of doubtful character and comes down to us from 1831, at which time a boy showing this anomaly is said to have been on exhibition in Bremen.

Two peculiar changes in the texture of the hair are reported by Ferber (Virchow's *Archiv*, 1866, xxxvi., 598). Both patients were of nervous temperament, and their hair in a few hours would change from being soft and curly to become straight and bristly. After a time the hair would assume its natural condition.

NODULI LAQUEATI is an anomaly of the hair in which it seems to tie itself into knots. The loops of the knots catch dust. The hair looks as if infested with nits, but under the microscope it is seen that it is the knots that give this appearance. *George Thomas Jackson.*

ATROPHY.—(Wasting, lack of nourishment, wasting of the body due to defective nutrition.) The word is at the present time used in pathology to signify the decrease in size of an organ or tissue which results either from a decrease in the size of its individual elements, or from a diminution in the number of these elements, or from a combination of these two factors. We may speak, therefore, of a quantitative and of a numerical atrophy, but no practical distinction can be made between these two forms, as a diminution in the number of the tissue elements almost always accompanies a decrease in size.

In its narrowest sense the term is used to indicate a decrease in size of the individual histological elements due to a simple loss of substance without including the idea of other retrograde changes. The essential idea of atrophy is, therefore, separated from that of degeneration, and the term should be applied only to those conditions in which the primary pathological change is a loss of bulk.

On the other hand, the meaning of atrophy must not be confused with the ideas expressed by the words agenesia, hypoplasia, and aplasia. These terms, unfortunately, have been used rather loosely as synonyms with atrophy, but the best usage is to assign to each one a distinct technical meaning: agenesia, total failure of development or destruction of a part after it has begun to develop; aplasia, marked defective development of an organ; hypoplasia, under-development; atrophy, decrease in size after development has been reached. From this it will be seen that the causes leading to these changes operate at different periods of life; thus agenesia and aplasia are the results of disturbances in early fetal life; hypoplasia the result of changes occurring later, but at any period before complete development is reached; while atrophy may occur at any time in the history of the organism when any tissue or structure has reached its full anatomical and physiological maturity. The latter process is, therefore, a retrograde change occurring in parts that were originally normal and perfectly formed.

All stuntings and defective development of the body and its parts, either intra- or extra-uterine, are to be considered under the head of aplasia or hypoplasia, and not under that of atrophy. But the cells of an aplastic or hypoplastic organ may also undergo a decrease in size due to the same causes that lead to atrophy of perfectly formed organs. A hypoplastic organ may become atrophic; hence in its broadest sense the meaning of atrophy must be extended to include the retrograde decrease in size of imperfectly developed cells and organs. The fundamental idea of atrophy is, therefore, *a retrograde decrease in size of either perfect or imperfect cells.*

The decrease in size and the disappearance of the tissue elements in atrophy must be referred to a failure of the processes of restoration to keep equal step with the never-ceasing processes of tissue waste and destruction. All cells possess a histogenetic energy which is manifested in the functions of nutrition, assimilation, and reproduction. For all cells, for every organ, for every individual, and for every species there is a certain limit to the ultimate amount of inherent histogenetic energy. This limit is fixed by intrinsic forces acquired through the agency of external forces in the process of evolution of the species, and represents the physiological duration of life of each organ, and of each individual of that species. Could all external injurious influences be avoided the organism would after a certain period of time come to a physiological death through physiological atrophy, or, in other words, as soon as such a limit of histogenetic energy is reached that the necessary vital functions of the body fail to be properly performed in a degree sufficient to preserve life. We may, therefore, speak with propriety of a physiological or histogenetic atrophy.

Further, the histogenetic energy of the cells is to a certain extent maintained by means of certain stimuli, and as a result of the removal of these stimuli an inaction atrophy may result. Atrophy must result also from any deficiency or disturbance in the supply of nutrition, and likewise excessive consumption or waste of tissue must lead to atrophy. Further, atrophic changes may be set up by mechanical hindrances to growth, as in pressure, constriction, etc. On the other hand, the loss of normal pressure or tension may produce atrophic changes in the tissues so affected, and the separation of an organ or tissue from its nerve centres is usually followed by a similar condition. We may consequently classify the various forms of atrophy as histogenetic, inaction, lack of nutrition, neuropathic and pressure atrophy. Only the first of these, the histogenetic form, is essentially an active process: the cells are unable to assimilate the food brought to them. The other forms are passive in character: either insufficient food is brought to the cells, or harmful substances are formed which injure their nutritive function.

Histogenetic or Physiological Atrophy.—This form of atrophy is the result of a decrease in the histogenetic energy of the cells. As stated above, the potential energy of each cell and organ is limited in direct relation to the part which its function plays in the general economy of the organism. Hence the duration of life varies with different organs and tissues, and in the life history of the organism from the very beginning the processes of atrophy go hand in hand with those of development. In the earliest stages of growth up to the time of puberty there is a preponderance of cell growth over cell decay; in adult life there is a period of equilibrium; but with the beginning of old age the loss of histogenetic energy is shown in the fact that cell decay preponderates over cell restoration.

Even in earliest fetal life certain structures fulfil their

function and pass out of existence. In the formation of the fetal placenta portions of the membranes disappear at a very early stage, and in the development of the chorion there is from the beginning a progressive atrophy of the villi. The placenta at term must be regarded as a senile organ. Portions of the fœtus itself, as the Wolffian bodies, the Wolffian ducts, the ducts of Müller, the umbilical vesicle, the omphalo-mesenteric duct, etc., disappear very early, even in the period of most vigorous development of the fœtus. Numerous blood-vessels undergo obliteration even before birth, and very soon after this event the closure of the ductus Botalli and the umbilical vessels takes place. Likewise the casting off of the umbilical cord must be considered under this head; and later the shedding of the milk teeth is another example of the disappearance of structures that have fulfilled their aim and reached their limit of existence. The disappearance of the thymus after the fifteenth year is one of the most striking of the histogenetic atrophies. During the period of most active development it is one of the largest lymph glands of the body, but soon after puberty it disappears, becoming entirely replaced by fat tissue. During middle life single portions of tissues, as certain portions of the petrous and sphenoid bones, vanish. Hyaline cartilage may also be regarded as an essentially temporary structure, as in many individuals it entirely disappears from the body during middle life and is replaced by bone.

Some organs do not atrophy, but very early suffer a cessation of growth, so that they become no larger in the adult than in the new-born (adrenals, male mammæ, etc.). The failure of these organs to increase in size is not due primarily to any failure of nutrition or disturbance of circulation, and can be explained only by the assumption that the original histogenetic potentiality of growth has reached its limit. The atrophy of the ovaries and of the uterus after the forty-fifth year, before all of the ova are discharged, must be similarly explained. In the case of the ovary the primary change is in the blood-vessels of the organ, which normally show sclerotic changes before the blood-vessels of any other part of the body. The menopause is essentially a process dependent upon changes in the ovarian vessels, and to these changes the atrophy of the Graafian follicles must be considered secondary. The atrophy of the ovary at the menopause may, therefore, be explained by the assumption that the histogenetic energy of the ovarian vessels has an earlier limit than that of the systemic vessels.

In the atrophy of old age (senile atrophy) the blood-vessels, lymphadenoid tissues, muscles, and bones suffer most. The changes in facies, posture, and gait of the old individual are dependent upon these conditions. The brain may also undergo a marked atrophy, and of the internal organs the kidneys, liver, and lungs may suffer to a greater or less extent. On the other hand, there are certain organs and tissues which undergo but little senile change: the formation of the red blood cells continues in old age without decreased energy, and defects of epithelium, blood-vessels, and connective tissue are as completely repaired as in earlier life. There are very marked individual differences as to the organ which shows the greatest degree of senile change: environment, disease, etc., may lessen the inherent histogenetic energy of certain organs so that they may become prematurely senile, or atrophy to a greater degree than others. Further, there are individual differences dependent upon the amount of histogenetic energy inherited; the variation in this is a well-known pathological fact. Nevertheless, in spite of these individual differences typical senile atrophy is always confined to certain organs and tissues.

Senile atrophy is not only active but is also passive, as it depends not only upon the gradual decrease of energy on the part of the cells, but is in part the result of the narrowing and obliteration of the blood-vessels supplying nutrition to the cells. The changes in the blood-vessels are, therefore, to be regarded as the most important of the senile processes, and it is probable that the chief part of the glandular atrophies is secondary to these.

Atrophy of Disuse.—The histogenetic energy of many organs and tissues is dependent upon certain regular stimuli. If these stimuli are removed for any length of time an atrophy results which we may call an inaction or disuse atrophy. The atrophy of the optic nerve after destruction of the eyeball; the atrophy of peripheral nerves and portions of the spinal cord following amputations of the limbs, are familiar examples of this form. Likewise, if through any influence glands or muscles remain inactive for a certain period of time atrophic changes occur. In the case of muscle the loss of substance is usually not very great. The testicles are said to become atrophic in cases in which sexual abstinence is extended over a long period of time, and even the bones undergo a loss of substance when kept in undisturbed rest for several years. Further, the physiological atrophy of the uterus and mammæ after pregnancy may be included in this class.

In the case of nerves, glands, and muscle, inaction atrophy is essentially active, but as the result of the cessation of function there is also a decrease in the nutritive activity of these structures and a lessened blood supply which leads to further disturbances of nutrition. In other tissues the chief cause of the atrophy is a decrease in the nutrition of the unused part, but with this there is also a lessened power of assimilation. The involution of the puerperal uterus, by means of which the organ is restored to very nearly its original size, is a very complicated process, partly atrophy and partly degeneration, involving all of its structures, endometrium, muscle, and blood-vessels. It is essentially active in its nature, but the obliteration of its enlarged blood-vessels through sclerotic changes and the organization of thrombi plays a very important part in the retrogression.

If the conditions leading to the inactivity of certain parts are in operation during the period of development and the tissues in consequence of disturbed nutrition fail to reach their normal size, the process is to be regarded in the light of a hypoplasia rather than of atrophy. It is, however, impossible in all cases to separate these processes, since in hypoplastic organs there may be an atrophy or disappearance of tissues which had undergone a certain degree of development.

Atrophy Dependent upon Impaired Nutrition.—If there is a deficiency in the amount of nutritive material brought to the cells these will undergo atrophic changes. The degree and rapidity of the atrophy are in direct relation to the degree of metabolic change of which the affected organ or tissue is capable. Hence adipose tissue quickly disappears if fat or fat-forming substances are not adequately supplied to it. The bones become softened and fragile if the supply of lime salts is withheld for a period of time, and it is also probable that a decrease in the amount of hæmoglobin contained in the red blood cells is the result of deficient absorption of iron. The nature of rachitis, osteomalacia, and the various forms of anæmia is as yet but little understood, and these diseases may be the result of more complicated disturbances than the mere withdrawal of certain food elements.

Local atrophies may result from disturbances in the blood supply of certain regions following arterio-sclerosis, thrombosis, or inflammatory processes involving the vessels. Degenerative changes almost invariably accompany this form of atrophy. If the blood supply of any part is completely shut off, necrosis results. When there is an insufficient supply of food to the body as a whole, or if the fluids of the body are not adequately restored, a general atrophy of the body takes place. The fat, muscles, blood, and abdominal organs suffer to the greatest degree. The fat disappears first and may be reduced to seven per cent. of its original amount. The muscles may lose as much as fifty per cent. in weight. Of the abdominal organs the liver, spleen, and intestines suffer most. The brain, spinal cord, bones, and heart muscle undergo but little loss of substance even in cases of death from starvation. Lipomata remain unchanged

in spite of the almost complete loss of the normal fat tissue of the body. This remarkable phenomenon has not as yet been explained.

The histogenetic energy of the cells is most intimately connected with their physical and chemical integrity, and disturbances of this lead to a decrease of this energy. The presence of certain foreign elements in the circulation leads occasionally to atrophy associated with degenerative processes. The protracted use of iodine may cause atrophy of the thyroid and mammary glands, and in chronic lead poisoning the extensor muscles of the forearm may become atrophic.

Pressure Atrophy.—Closely allied to the atrophy resulting from insufficient nutrition is that produced by continued slight pressure. As the result of artificial mechanical pressure may be mentioned the examples of "corset liver" and "corset spleen" the constriction produced by rings, belts, and garters, the Chinese foot, the flat head and flat nose of certain Indian tribes, etc. Skin, muscles, and bone may disappear as the result of pressure from aneurisms and tumors. Varicose veins may likewise lead to the atrophy of the neighboring structures. In scoliosis, genu valgum, and pes valgus, atrophy of certain portions of the joints may be caused by the abnormal pressure produced by an oblique position of the bones. After loss of the teeth the alveolar processes of both jaws may disappear as the result of the pressure brought to bear upon them in mastication. The skull cap may present erosions which have been produced by the pressure of atheromata of the scalp or by hypertrophic Pacchionian bodies. In hydrocephalus and hydronephrosis the brain and kidneys respectively may undergo extreme atrophy. Further, atrophic changes may be caused in any part of the body as the result of pressure from inflammatory exudates.

FIG. 380.—Pressure Atrophy of the Spinal Column, Caused by the Encroachment of an Aneurism of the Aorta. (After Ziegler.)

The various forms of pressure atrophy are caused, as a rule, by slight pressure continued through long periods of time. It is the result of direct injury to the tissue and of circulatory disturbances. It is therefore passive in its nature. If the pressure is so great that the blood-vessels become closed, degeneration and necrosis must follow. In many cases the causes of the atrophy resulting from pressure are complicated, mechanical force and disturbances of nutrition playing the chief parts in its production.

Neuropathic Atrophy.—The question of the existence of trophic nerves and trophic centres and their relation to the individual tissues is still unsettled, and the existence of a neuropathic or trophoneurotic atrophy must at the present time be viewed more in the light of a possibility than as being an established fact. It is not to be doubted that as the result of disturbances of innervation both atrophic and degenerative changes arise, but it is probable that these changes are not entirely dependent upon the loss of nerve influence, but for the greater part are secondary to the loss of functional activity and to disturbed nutrition caused by vaso-motor changes in the regions supplied by the affected nerves. As a result of these changes inflammations are easily set up, even by slight causes which ordinarily produce no lesions, and the result of the inflammatory process may be either atrophic or degenerative in its nature. The majority of the changes following disturbances of innervation are not of the nature of a true atrophy, but are degenerative in character. The application of the term atrophy to these processes is justifiable only by the fact that the ultimate condition is a loss of tissue.

Disease of the anterior horns of the spinal cord or of the motor roots is followed by atrophy of the corresponding nerves and muscles. Anterior poliomyelitis, progressive muscular atrophy, and bulbar paralysis are well-known examples of this form of atrophy. In syringomyelia and tabes dorsalis atrophy of the bones and joints not infrequently occurs. Injuries of the peripheral nerves may be followed by thinning of the skin, exfoliation, loss of hair, and atrophy of the glands of the skin. Disease or injury of the nerve trunks of one side of the face may lead to atrophy of the tissues of that side. Unilateral affections of the brain in fetal life or during early childhood may cause an atrophy of the opposite side of the body (congenital or infantile hemiatrophia). General atrophy of the body occurs in progressive paralysis and to a less extent in melancholia and dementia. It is denied by many authors that these forms of atrophy are neuropathic, and it is much more probable that vaso-motor disturbances, loss of function, and general as well as local disturbances of nutrition are the chief factors in their production.

Atrophy Due to Excessive Waste.—In all conditions in which the repair of the tissue is exceeded by tissue consumption a loss of substance must occur. In fetal life and in the period of early development only a portion of the substances taken into the body is completely oxidized, the greater part is used in the building up of tissue. In adult life the larger part is burned up, the smaller remaining portion is used in tissue repair. The two processes of waste and repair stand in different relations to each other at different periods of life, and must be considered as independent processes. This is very clearly shown in those pathological conditions in which tissue waste exceeds tissue repair. Over-use of any organ leads to fatigue, poisonous products of metabolism are retained, and the cells are not given sufficient time for rebuilding. If a condition of chronic fatigue develops as a result of chronic over-use anatomical changes occur. Chief of these is a loss of substance. The brain is the most important organ which may be so affected. Of the glandular organs the testicles most frequently suffer. Atrophy of the heart and voluntary muscles may also occur as the result of over-use. The failure of compensation in chronic valvular disease is also to be placed in this category.

Repeated severe hemorrhages, chronic suppurative processes, long-continued excretion of albumin, diabetes, fever, rapidly growing tumors, and many other similar processes produce general wasting of the body with marked atrophy of certain tissues. In general the nature and course of the various cachectic atrophies are very closely allied to senile atrophy, and the microscopical appearances are identical.

Atrophy Caused by Decreased Tension.—Through a permanent loss or decrease in the normal tension, as in the case of muscles, tendons, fasciæ, and blood-vessels after amputations, or of tendons after tenotomy, atrophy may take place. The involution of the puerperal uterus may also be considered under this head.

A large number of conditions, such as the decrease in size of the orbital cavity after removal of the eyeball and of the sockets of joints after unreduced dislocations, are not properly included in this class, as the decrease in size of the cavity is not of the nature of an atrophy, but

is usually caused by an increase of tissue in and about the cavity.

MACROSCOPICAL APPEARANCES.—The most striking change in atrophic organs is their decrease in size. This is directly dependent upon the decrease in size and the diminution in number of the structural elements. The

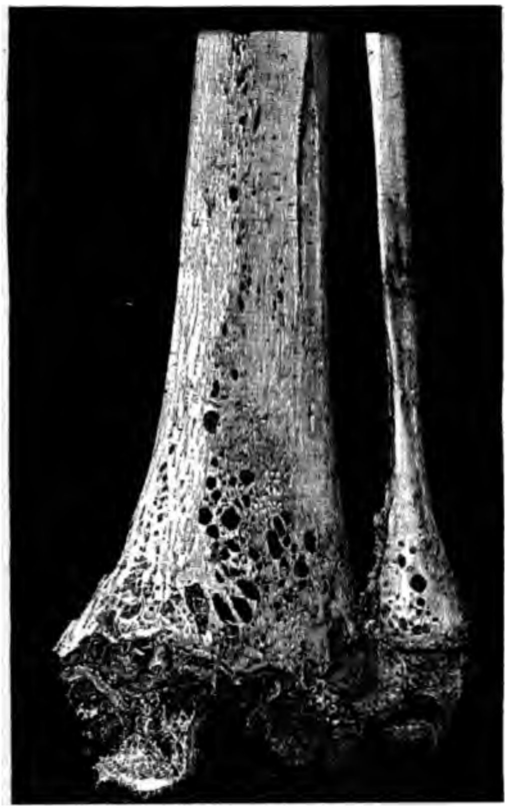


FIG. 381.—Excentric Atrophy of the Lower Ends of the Tibia and Fibula, with Osteoporosis. Natural size. (After Ziegler.)

muscles, kidneys, liver, and spleen show this decrease in size to the most marked degree. In extensive atrophy of the muscles as seen in progressive muscular atrophy the disappearance of the tissues may be so marked that the impression is given that there is nothing between the skin and the bone (so-called living skeleton). In many cases, however, there is a deposit of fat in the atrophic tissues which may be so extensive that the normal size may be preserved or an actual increase may take place (atrophia musculorum lipomatosa). The atrophic liver and heart may likewise be increased in size through fatty infiltration.

The size of atrophic lungs may be increased through the stretching of the atrophic alveolar walls and the consequent dilatation of the air spaces (atrophic emphysema).

In the case of atrophy of fully developed bones no decrease in size takes place, but the Haversian canals and medullary cavity become enlarged (excentric atrophy or osteoporosis). The spleen as a rule suffers a symmetrical decrease in volume, while the liver usually shows more marked loss of substance in the left lobe than in the right.

If the atrophy of an organ proceeds symmetrically in all parts a uniform decrease in size results with preservation of normal form. It, however, progresses most frequently with greater rapidity in one part than in another, and as the result of this unequal atrophy nodules and furrows are formed so that the organ comes to present a nodular or granular surface. This is especially marked in atrophy of the glandular structures, liver, kidney, etc. As a rule atrophic organs contain less blood and are drier than normal ones. The increase of connective tissue, either relative or actual, causes an increase in consistency with loss of elasticity. As a result of the decreased blood content the natural color of the organ stands out more distinctly; hence atrophic muscle, especially heart muscle, is much browner in color than normal. An increase of the normal pigment or an increased deposit of hæmatogenous pigment is also a very frequent accompaniment of atrophy (brown atrophy of heart and liver). In other cases the color of the atrophic organ is lighter or more grayish than normal because of the relative or actual increase of connective tissue. In all cases in which much fat is deposited the color becomes yellowish.

MICROSCOPICAL CHANGES.—The microscopical examination of atrophic organs shows a decrease in size and a diminution in number of the normal elements. This may occur without other changes, or the atrophy may be accompanied by a deposit of fat or pigment, or an increase in the amount of the normal pigment, or it may occur in association with various degenerative processes. We may therefore distinguish: *simple atrophy, fatty atrophy, pigment atrophy,* and *degenerative atrophy.* Fatty and pigment atrophy are so closely related to simple atrophy that they are to be considered as simple atrophy followed by or associated with fatty infiltration and pigment formation. They should be carefully distinguished from the true degenerative atrophies in which changes in the nature of the protoplasm occur from the very beginning. As a result of these changes new substances are formed in the cells or about them (mucous, fatty, hydropic degenerations; amyloid, etc., deposits). In these conditions, especially in the case of the pathological deposits and infiltrations, the atrophy of the cells must be regarded in many cases as a secondary process.

As a rule the more highly specialized portions of the tissues suffer to a greater extent than the connective-tissue framework. This may be unchanged or, as most frequently occurs, increased in amount. In the newly formed connective tissue there is usually a greater or less degree of fatty infiltration. Through the increase of connective tissue and the fat deposit the normal pressure upon surrounding structures may be preserved unchanged. The fatty infiltration may, therefore, be regarded as being of the nature of a compensatory process.

In atrophy of striped muscle the contractile substance disappears while the nuclei of the endomysium proliferate to a greater or less extent. In atrophy of the lung the alveolar walls become greatly thinned, the capillaries disappear, and the air spaces become increased in size or

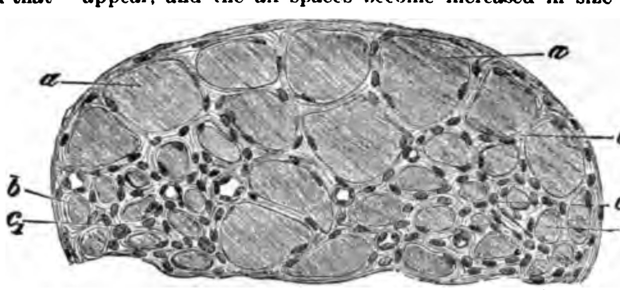


FIG. 382.—Section of an Atrophied Muscle, from a Case of Progressive Muscular Atrophy. (Müller's fluid; Bismarck brown.) *a, a,* Normal muscular fibres; *b,* atrophic muscular fibres; *c,* perimysium internum, the nuclei of which, at c_1, seem to be increased in number. Magnified 200 diameters. (After Ziegler.)

confluent through the disappearance of the wall. As a result of the obliteration of many of the smaller capillaries the larger vessels show a state of chronic congestion. The liver lobules become very much smaller in atrophy of that organ, the connective tissue of Glisson's capsule is relatively or actually increased, and is more hyaline in character, resembling scar tissue. The liver rods and cells are decreased in size, and there is a great variation

in the size of the individual liver nuclei, many of which show a compensatory hypertrophy. The central veins and capillaries are congested, and the liver cells of the central zone of the lobule contain much hæmatoidin, while those of the peripheral zone show an increased amount of fat.

In the atrophic kidney there is a decrease in the size of the tubules due to a decrease in size and to a diminution in number of the epithelial cells. Many tubules may be found containing few cells or completely collapsed. As a result of the loss of intervening tissue the glomeruli are brought closer together, so that from twenty to forty may be found in one low-power field. The epithelium and capillaries of the glomeruli also disappear, and as a result numerous obliterated glomeruli are found. In atrophy of the central nervous system the ganglion cells disappear or become smaller, while the neuroglia remains in normal amount or becomes increased. Atrophy of the lymph glands and spleen is shown by a disappearance of the follicles and a diminution in the number of the lymphadenoid cells. The trabeculæ are brought more closely together, and the finer stroma is increased in amount. In atrophy of bone the bone substance is decreased in amount and the marrow spaces are increased. With this there is usually an increase in the fatty marrow, but it occasionally disappears, leaving cystic spaces filled with fluid.

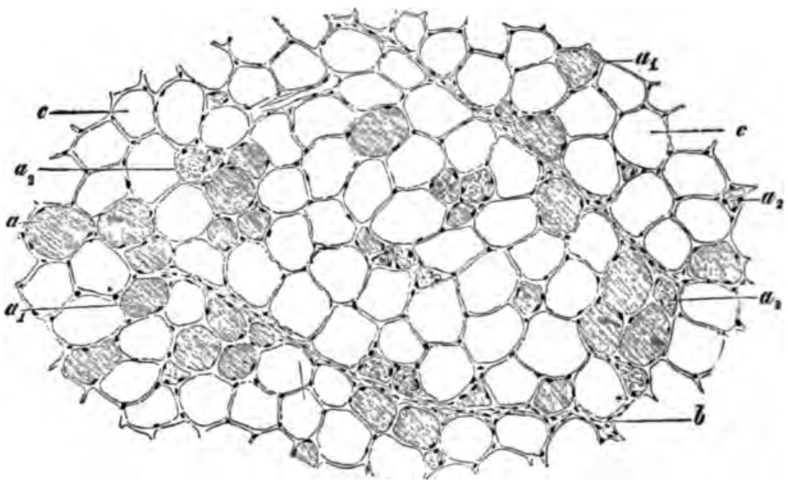


FIG. 383.—Lipomatosis of the Muscles of the Calf of the Leg, Together with Atrophy. (Müller's fluid, carmine.) Transverse sections of a normal (a) and an atrophied (a_1) muscular fibre; a_2, transverse section of a tubular sarcolemma containing contractile substance in a condition of disintegration; b, bands of connective tissue; c, fat tissue. Magnified 60 diameters. (After Ziegler.)

COURSE.—The course of the various forms of atrophy depends wholly upon their nature. Total atrophy occurs as the result of the exhaustion of the inherent histogenetic energy, as in the case of many of the fetal structures, the thymus, etc. In partial atrophies due to other causes, such as disturbances of nutrition, pressure, etc., a greater or less degree of restoration is possible in all structures in which the histogenetic limit has not been reached. If the causes leading to atrophy operate in the early periods of development, agenesia or aplasia may result. Certain organs, as the thyroid or sexual glands, may be thus affected and their lack of development may lead to retarded growth of other tissues. As stated above, these processes are not of the nature of true atrophies, but it is difficult in all cases to make sharp distinction. The atrophy of certain fully developed organs likewise may affect the growth of other organs or even of the whole body, as in progressive muscular atrophy where atrophic changes in the bones follow those in the muscles.

In so far as the function of the organ is concerned, the atrophy of its elements is of the greatest importance. Atrophic muscles lose their contractile power, atrophic glands their secretory function, osteoporotic bones are easily broken, and atrophic skin is easily injured by a very slight trauma. Further, the atrophy of one organ or set of tissues disturbs the function of other organs and leads to a general diseased condition of the organism.

The prognosis in atrophy is favorable only in those pathological conditions in which the cause of the atrophy may be removed, and in tissues in which the physiological limit of growth has not been reached. Atrophy of the vital organs, heart, medulla oblongata, kidneys, respiratory muscles, etc., not infrequently leads to death. There may also result a complete disappearance of certain structures caused by the atrophy of the matrices which form them. In atrophy of the periosteum the bone disappears, in atrophy of the skin there is a loss of the hair and nails, and in atrophy of the lymph glands there is a decrease in the formation of leucocytes.

It is evident that only the purely passive forms of atrophy admit of treatment. The removal of the cause and the restoration of the normal nutrition are the chief indications.

Aldred Scott Warthin.

ATROPIC POISONS.—The natural order *Solanaceæ* comprises many plants possessing actively poisonous properties. Among these the more important are: *Atropa belladonna*, deadly nightshade; *Hyoscyamus niger*, henbane; *Datura stramonium*, thornapple or Jamestown weed; *Mandragora officinale*, mandrake; *Scopolia Japonica*, Japanese belladonna; and several species of *Duboisia*. It is worthy of note that several of the most widely used foods—*e.g.*, potato, tomato, and egg plant—are derived from plants of this order.

The poisonous qualities of the *Solanaceæ* depend on well-marked alkaloids, analogous in composition and properties, notably as regards the power to produce dilatation of the pupil, for which reason the term *mydriatic alkaloids* has been applied to them collectively. Since the toxicology will include the effects of both the plants and the active principles, it will be more satisfactory to consider them under the title of the "Atropic Poisons." The deadly nightshade, *Atropa belladonna*, is the most important of the group, and its alkaloid, atropin (atropina, U. S. P.), has been extensively used by ophthalmologists, but of late years it has been often replaced by a derivative, homatropin, and by another natural alkaloid of the class, scopolamin; the effects of these being more transient than those of atropin. According to recent investigations, the so-called daturin—derived from *Datura stramonium*—is identical with atropin, but commercial daturin often contains some hyoscyamin. Statistics collected by Witthaus show that of the reported cases of poisoning by the plants of this class or their alkaloids, over sixty per cent. are by belladonna or atropin, and next in order by *Datura stramonium*. The majority of cases were accidental.

The *symptoms* produced by toxic doses of the preparations of belladonna usually manifest themselves within an hour, and are marked and characteristic. They are heat and dryness of the mouth and throat, increasing to a feeling of burning or constriction, difficulty of swallowing, giddiness, nausea and vomiting frequently, but not invariably; great mental excitement, delirium, and hallucination, often decidedly maniacal or hysterical. The circulation is decidedly affected, the pulse being quickened, the face becoming red and turgid, and in some instances a scarlet eruption has appeared over the body.

Dilatation of the pupil with insensibility to light and impairment of vision is a usual and important symptom. The mental symptoms often take the form of wild and uncontrollable laughter. The following case, detailed by Taylor ("Treatise on Poisons"), illustrates the clinical history of belladonna poisoning. A boy, aged fourteen, ate about thirty belladonna berries. In about three hours it appeared to him as if his face was swollen, his throat became hot and dry, vision impaired, objects appeared double, and seemed to revolve and run backward. His hands and face were flushed and his eyelids swollen, and occasional flashes of light were experienced. He tried to eat, but could not swallow on account of the state of his throat. In endeavoring to walk home he staggered, and felt giddy whenever he attempted to raise his head. He was incoherent, frequently counted his money, and did not know the silver from the copper coin. His eyes had a fixed and brilliant look, he could neither hear nor speak plainly, and was very thirsty; he caught at imaginary objects in the air. There was headache, but no vomiting nor purging. These symptoms were much the same nine hours after the taking of the poison. The pupils were so strongly dilated that there was merely a narrow ring of iris; the eyes were quite insensible to light, the eyelids did not close when the hand was passed suddenly over them, but the nerves of common sensation were unaffected. The pulse was 90, feeble, and compressible. He continued in this state for two days, but gradually recovered.

Fatal cases usually terminate in coma, less frequently in convulsions.

The *treatment* of belladonna (or atropin) poisoning is both direct and physiological. Free evacuation of the stomach by means of emetics or the stomach pump should be resorted to; as antidotes, animal charcoal or tannic acid may be given. The former has been found efficacious by actual experiment on the human subject; it acts by absorbing the alkaloid; tannic acid renders it insoluble. Both these agents are, however, only temporary; they do not set aside the necessity for evacuating the stomach or using other remedies. Since physostigmin—the active principle of the Calabar bean—and also morphin cause contraction of the pupil, they have been naturally suggested as physiological antidotes to atropin, and clinical experience has borne out this view. The hypodermic use of these agents should therefore be cautiously employed, the condition of the pupil and the general nervous symptoms being used as guides to the medication.

Many of the recorded cases of belladonna poisoning have recovered under treatment. When a fatal result takes place, no special or characteristic post-mortem appearances are discoverable.

There are no striking or easily applied chemical tests for atropin. It may be identified by its physiological action, dilatation of the pupil. *Henry Leffmann.*

ATROPINE. See *Belladonna*.

AUDITION.—Audition or hearing is the result of processes by which certain vibrations of physical media are taken up by a peripheral sense organ, the ear, and transformed into nerve stimuli which excite in consciousness sensations of a peculiar kind. These sensations we know as *sound*. They are a function of a certain part of the cerebral cortex. Unfortunately, it is also the rule to designate by the name of "sound" those physical vibrations which are the objective cause of sound sensation but which have nothing in common with it.

This article will be chiefly limited to the treatment of objective or physical sound and the manner in which it affects the mechanism of the ear in giving rise to impulses in the auditory nerves.

Physical sound, as contrasted with sound sensation, is due to vibrations of particles of solid, liquid, or gaseous media. In its vibration a particle may move back and forth in a straight line, as in the transmission of an air wave or in the propagation of a tremor longitudinally along a rod of metal; or it may describe a more or less elliptical or circular path as in a wave of water, and tranverse to the direction of wave movement. When a particle is forced from its position of equilibrium, the force with which it tends to resume that position is a measure of the elasticity of the substance of which it forms a part. Elasticity is the property by virtue of which vibrations are propagated.

Transverse and Longitudinal Vibrations. Waves of Sound.—The vibration of particles gives rise to waves having definite form, length, and rate of progress. The waves most familiar to us are those seen on the surface of water formed by an up-and-down motion of the particles in an elliptical curve. The vibration is *transverse* to the direction and length of the wave, and the amplitude or depth of the wave and that of the vibration correspond. The wave length is the distance measured from crest to crest or hollow to hollow; it has no necessary relation to the amplitude of vibration. A stretched string or a tuning fork also executes transverse vibrations, when plucked or rubbed in the usual way. But if a stretched string or a rigid rod be scratched at one end the particles there will be set in oscillation back and forth (longitudinal vibration), and this vibration will be transmitted as a wave along the string or rod and may be heard as sound at the further end, but will make no visible movement. It is important to consider how these longitudinal waves are formed. The particles which are struck or scratched at the end of the string or rod are forced against those immediately adjoining, these in turn crowd upon the particles in front; the energy of the first displacement measures the degree of crowding or condensation thus produced. The particles unnaturally strained together spring away from one another by virtue of their elasticity, and their energy of movement carries them beyond their position of rest, making the number of particles at the previous point of condensation less numerous than normal, thus producing a condition of *rarefaction* as a result of the oscillation. The forward vibration of the particles is thus transmitted as a phase of *condensation* to successive layers of the substance traversed, each condensation being succeeded by a complementary *rarefaction*. The two phases of condensation and rarefaction make up the wave of sound. The length of the wave is the distance measured between two points of extreme condensation or rarefaction. This wave length has no necessary connection with the length of the path described by the individual particles whose motion gives rise to the sound wave.

Aërial vibrations resemble the longitudinal vibrations of solids and liquids in that the sound waves move in the same direction as the particles whose movement produces the waves. The amplitude of movement of the individual particles is very much less than the wave length produced by that movement. In the mobile air the path described by the particle is relatively great, but in a rod of wood or metal or under water, the excursion of each particle in its vibration is infinitesimal in its relation to the wave length or distance between successive condensations or rarefactions. The amplitude of movement of the vibrating particle is a measure of the energy which has been imparted to it, and it has extraordinary

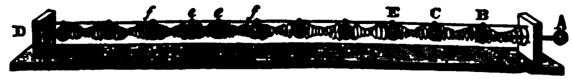


FIG. 384.—Illustrating Passage of an Air Wave. The balls, E, C, B, etc., represent air particles and the springs the elastic force restoring them to position. (After Tyndall on "Sound.")

physiological significance, for upon it depends the *loudness* of sound. In exact language, the intensity of sound sensation is proportional to the square of the amplitude of the vibrations which cause it. Tyndall in his work on sound illustrates by a diagram the method by which a "sound pulse" is transmitted (see Fig. 384). The apparatus consists of a series of wooden balls separated from one another by spiral springs (the balls represent

air particles and the springs the elastic force restraining their displacement). On striking the knob A, a rod attached to it impinges upon the first ball B, which transmits its motion to C, thence it passes to E, and so on throughout the entire series. The arrival at D is announced by the shock of the terminal ball against the wood, or, if we wish, by the ringing of a bell. Here the elasticity of the air is represented by that of the springs. The "pulse" may be reduced to such a degree of slowness that it can be followed by the eye.

Vibrations occurring in any medium may be transmitted by direct contact to another medium. Thus, when the bell of a stethoscope is applied to the chest, the vibrations of the chest wall are transmitted to the ear either by the air columns of the instrument or by its solid structure or by both. Vibrations of the bones of the skull are transmitted directly to the tympanic membrane and probably also to the lymph of the labyrinth.

The Production of Tones.—When the pendulum of a clock swings to and fro it might be supposed that a sound would be produced by each excursion of the rod, and this would be the case were not the air so mobile that its particles instantly retreat from the front to the back of the slowly moving pendulum, so that no sensible condensation, which is necessary to the production of a sonorous wave, occurs. That is to say, a certain suddenness of impulse is necessary to start an air wave. Such an impulse is developed when a mixture of oxygen and hydrogen are ignited by an electric spark. The heat generated by their union causes a sudden expansion which starts a sonorous wave which comes to the ear as a sharp report.

Simple Pendular Vibrations.—Suppose our pendulum to gradually increase its rate of movement; when it swings so fast as to accomplish one complete to-and-fro movement in about the one-sixteenth of a second a continuous sound of very low pitch should be expected.

In practice it is customary experimentally to produce sounds by the transverse vibrations of tuning forks set upon resonance boxes (see below). The effect of such vibration upon the air is illustrated in Fig. 385, in which the dark spaces, *a*, *b*, *c*, *d*, represent the phases of condensation, and the light spaces, *b'*, *c'*, *d'*, the phases of rarefaction of the air waves. The wave length is the distance measured from *a* to *b* or from *b'* to *c'*.

Such to-and-fro oscillations are known as *simple pendular vibrations*. They make no audible sound until they attain the rate of sixteen to twenty-four per second, according to the perceptive power of the hearer.

The Pitch and Loudness of Tone.—Instead of using the tuning fork as a source of sound the following familiar device would serve: Take a circular disc, A–B in Fig. 386, of cardboard or metal about twelve inches in diameter, and let it be perforated at equal intervals along a circle near its circumference. The disc is fastened at its centre to the axis of a wheel capable of rapid rotation. A bent tube, *m*, communicating with a bellows giving a continuous blast of air, is brought with its orifice over the circle of holes. When the disc is rotated and air is forced

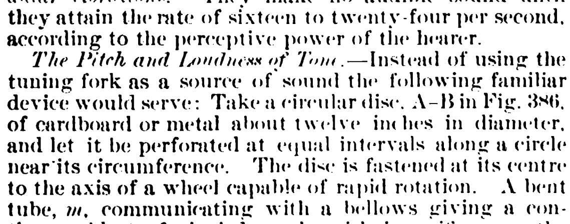


FIG. 385.—Diagram of a Series of Air Waves as Sent Out by a Tuning Fork. *a*, *b*, *c*, *d*, represent phases of condensation and *a'*, *b'*, *c'*, *d'*, of rarefaction. The wave length is measured from *a* to *b* or from *b'* to *c'*. (After Tyndall.)

through the tube *m*, a puff of air passes through the disc when one of the holes coincides with the open end of the tube, but the air stream is cut off by the solid plate between the holes. As the rate of rotation of the disc is gradually increased a low-pitched sound is heard when the puffs of air succeed one another at the rate of about sixteen per second, and as the rate of succession increases the sound becomes a well-marked *musical tone*, and the *pitch* of the tone is found to rise and fall with the number of puffs in a second which have caused it. If, instead of the single tube *m*, two tubes were used to convey the blast of air simultaneously through two different holes, the pitch of the sound would not be altered but its loud-

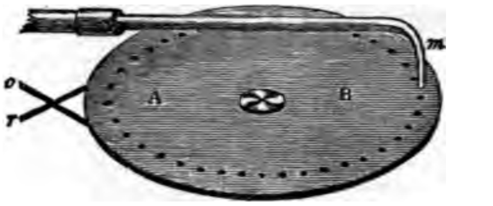


FIG. 386.—Illustrating the Production of a Musical Tone by Puffs of Air through a Perforated, Rotating disc. (After Tyndall.)

ness would be increased, because the two forces leading to condensation of the air would be added together. The demonstration of the laws of sound production in air owes much to an instrument called the *siren*, which is essentially elaborated from the perforated rotating disc.

The Range of Pitch of Audible Sounds.—As already mentioned, physical vibrations do not so affect the ear as to give rise to a *sensation of sound* until they succeed one another at the rate of sixteen to twenty-four per second. As the rate of vibration is progressively increased the pitch of the tone is raised until it becomes a painful squeak, and it is said that for most persons vibrations become inaudible when they reach a frequency of 16,000 per second, though some ears are still impressed with sounds caused by 38,000 to 40,000 vibrations in a second. Some of the lower animals can probably hear tones produced by still more rapid oscillations. It is a familiar experience that when a sounding bell or whistle, as of a locomotive, rapidly approaches, its pitch seems to rise, and then to fall as it recedes. The reason for this variation is that the motion of the locomotive adds to or subtracts from the number of sound waves reaching the ear in a given time. In the rendition of music a much narrower compass is employed, beyond which tones cease to have a pleasing character. The droning note of the sixteen-foot organ pipe and the lowest bass of the piano (C_1) represent a vibration rate of thirty-three per second. The highest treble of the piano has a vibration rate of 4,224 per second. Finely trained ears can distinguish differences of pitch represented by only half a vibration per second. As to the number of vibrations necessary to produce the sensation of sound, it has been found that two or three vibrations excite the sensation of a mere stroke; four or five vibrations are necessary to give a tone; and some twenty to forty are required to develop the full musical qualities of a tone. Thus from a physical scale representing aërial vibrations of indefinitely various rapidity the mind selects and appreciates as *sound* a small fraction, about a range of eleven octaves, and receives æsthetic pleasure from a still narrower range of about seven octaves.

Summary.—The foregoing discussion may be summarized in the statement that *simple tones are due to waves which are produced by the pendular vibration of the particles of elastic bodies. The intensity of the sound sensation increases as the square of the amplitude of vibration, and the pitch of the sound rises in proportion to the rate of vibration.*

The Origin of Sound Quality. Overtones.—It is but seldom that sonorous bodies are confined to the simple pendular vibration of their particles; but the sound wave is the resultant of several vibrations of different rates simultaneously imparted to the moving particles. When a stretched string is plucked or bowed at its middle it vibrates throughout its whole length, the greatest amplitude of movement being at the middle point, which moves to and fro like a pendulum. The musical note so produced is the lowest in pitch which the string is capable of giving. If the cord is held at its middle, or simply touched there with a feather, and a bow is drawn across one of the segments, vibration is renewed; but now the

string divides, as it were, into two halves with a point of rest, or a "node," between. Each inter-node or "ven-

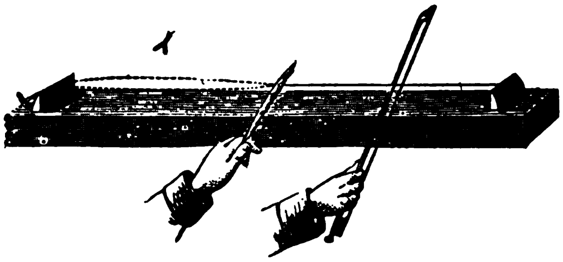


FIG. 387.

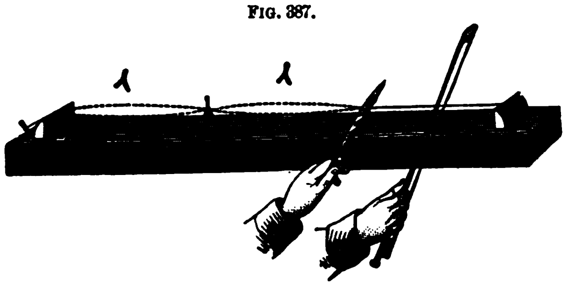


FIG. 388.

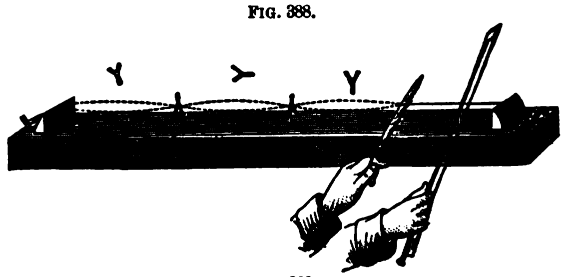


FIG. 389.

FIGS. 387-389.—Illustrating the Segmental, Transverse Vibration of a String. (Tyndall.)

tral segment" is half the length of the whole string, but its vibration is twice as rapid. The note given out is therefore the octave of that produced in the first instance. If the feather be applied at a point one-third the distance from one end, bowing the smaller segment will cause the string to break up into three equal vibrating parts, separated by two nodes or points of rest. In a similar way the string may be caused to vibrate in four, five, etc., segments. In each case the rate of vibration is as many times that of the whole string as there are segments of vibration. It is not necessary to keep the feather applied after the node is once formed.

The relative immobility of the nodes is illustrated by placing over the string a series of paper riders; when the string is thrown into vibration the strips of paper are violently displaced along the ventral segments but retain their position at the nodes (see Figs. 387, 388, 389). It is not possible to make a string vibrate as a whole without at the same time its breaking up, to a greater or less degree, into its vibrating segments. The result is that the oscillation of any particle is not a simple pendular movement, but is the algebraic sum of an indefinite number of such movements. The sound which is heard is a note in which are contained as many simple tones as there are separate rates of vibration. The tone produced by the movement of the string as a whole, which is the slowest rate of vibration, is known as the *fundamental tone*. The various tones produced by the segmental vibrations are known as *overtones*, *upper partials*, or *harmonic sounds*. The *pitch* of the compound note is identical with that of its fundamental tone. But the blending of the various segmental vibrations with the primary results in an extraordinary æsthetic modification of the sound, for thereby its *quality*, *timbre*, or *clang tint* is determined. Different sound-producing bodies may give out notes in which the number of upper partial tones is different. Again, certain partial tones occurring in the note of one musical instrument may be wanting in that of another, or a given harmonic may be different in intensity in two notes. As an outcome of these facts it has been demonstrated that *the quality of a compound tone depends upon the number, order, and relative intensities of its constituent partials.* Thus, a violin, a cornet, and a piano, though sounding a note of the same pitch, would never be mistaken for one another. But were all their overtones obliterated the three instruments would be indistinguishable to the ear.

The brilliancy and richness of musical notes is dependent on their wealth of upper partials. It is believed that a sound-producing body, like a stretched string, does not send to the ear a separate set of waves representing each of its segmental vibrations, but all the waves aroused by it fuse together into a single series of waves of peculiar form. Such a composite wave may be represented graphically by depicting under one another a series of waves having two, three, four, etc., times the rate of succession of the curve indicating the fundamental tone (Fig. 390). If a vertical line be drawn across the series representing the vibration rates of the various tones, and an algebraic addition be made of the distance of each point of intersection above or below the line of rest, the result will determine the position of the composite wave on the same vertical. It is evident that the *form* of the composite wave must change with every change in the number and relative prominence of the overtones; and the movement imparted by it to the tympanic membrane, and the wave generated in the labyrinthine fluids (see below) must have corresponding differences. Notes of different quality are

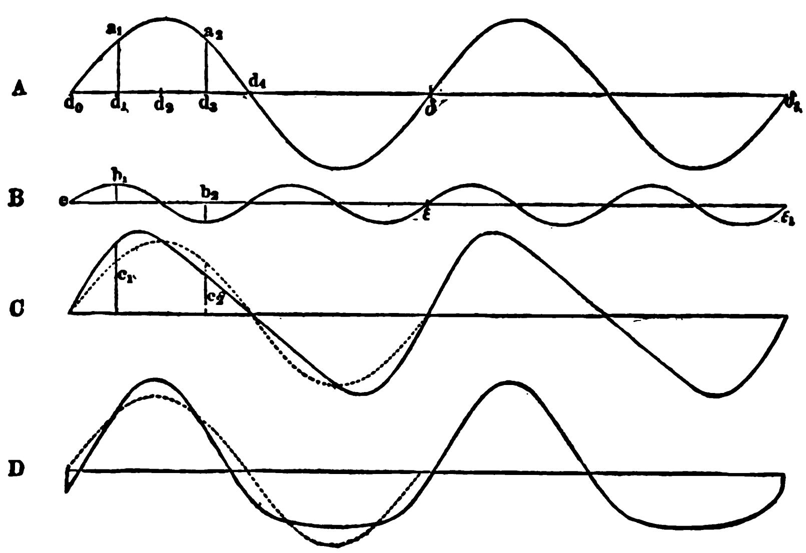


FIG. 390.—A Composite Wave (*C*, solid line), Formed by the Algebraic Addition of Two Simple Pendular Vibrations, *A* and *B*. *A* and *B* are in the same phase; but if curve *B* is moved to the right until *c* of *B* coincides with *d* of *A*, the phases of the curves will be different and their addition will give curve *D* (solid line). Such change of phase, however, does not change the musical quality of the composite note.

produced by composite air waves of different forms. But waves differing somewhat in form may still produce notes of the same quality; for if, in the graphical figure, one or more of the curves representing simple tones be slid to the right or left, the form of the composite wave will thereby be changed, but not the quality of the sound produced by it. In other words, change of "phase" of the partial tones does not alter the quality of the note.

Conditions Determining the Kind of Overtones.—The series of overtones accompanying the fundamental varies under definite conditions. Thus, in a metal rod fixed at both ends the longitudinal vibrations set up by rubbing the rod lengthwise produce tones whose vibration numbers are to each other as the odd numbers 1, 3, 5, 7, etc. The tones of a rod free at both ends have vibration rates proportionate to the even numbers 2, 4, 6, 8, etc. In a stretched string the order of the overtones depends upon the place at which the string is plucked or struck. In general, it may be said that no overtone is heard which requires for its production the existence of a node at the point plucked or struck.

Difference between Noise and Music.—Sound sensations may be divided into two groups, *musical tones* and *noises*. The requisite for the former is that the vibrations that produce them shall be *periodic*, that the motions shall repeat themselves at regular intervals. Irregularity of the vibration period or rapid breaks from one periodic motion to another produce the sensation of "noise." The singing voice restricts itself chiefly to the musical notes formed by periodic vibration of the vocal cords; but in articulate speech the distinguishing consonantal sounds are chiefly noises.

Sympathetic Vibration. Resonance.—Every elastic body is capable of *sympathetic vibration;* that is, air waves beating upon it at its own natural rate of vibration set it into corresponding motion. In the same manner a heavy pendulum may be forced into violent movement by exceedingly light taps with the finger, the only necessary condition being that the impulses imparted by the finger be exactly timed to the periodic motion of the pendulum or to some multiple of it. A body capable of sympathetic vibration with some particular tone is set into vibration by that tone, and reinforces or magnifies it whether the tone exists alone or as the fundamental of a complex note, or is contained in the latter simply as an upper partial. The property of increasing the intensity of sound by sympathetic vibration is known as *resonance*. The tone of a tuning fork held in the fingers is scarcely heard, but becomes plainly audible when the stem is touched to a wooden table top. Forks used for experiment are usually attached to special "resonance boxes." The sound of the pianoforte owes its volume to the sympathetic resonance of its sounding board and the air contained in the instrument. Confined bodies of air are, on account of their low density, especially easily set into sympathetic vibration. Helmholtz constructed and used as resonators a series of hollow brass spheres with a perforated conical projection at one pole for insertion in the ear, and a larger opening diametrically opposite (Fig. 391). The size of the spheres was graduated so that the fundamental tone of the contained air body represented various determined vibration rates. Each resonator picks out from a compound note, sounded near, that upper partial which is its own fundamental tone and greatly magnifies the intensity of that particular overtone. In this way a complex musical note may be analyzed into its constituent simple tones. Conversely, Helmholtz was able to reconstruct a complex note by simultaneously sounding a series of tuning forks, and appropriately regulating the intensity of the various simple pendular vibrations by means of resonators.

FIG. 391.—The Resonator of Helmholtz.

The vowel sounds of the human voice owe their difference of quality to the adjustment in size and shape of the resonant air chambers above the vocal cords by which now one, now another set of overtones is magnified.

That apparently simple tones are actually made up of a number of partials, having rates of vibration which form simple multiples of the fundamental tone, may easily be demonstrated at the open piano. If any note, as C in the bass clef, be struck while the key of its octave *c* is depressed, and then the struck string be damped, it will be found that the octave *c* rings out with its proper note. So in turn the *g* above that, the second octave and the *e* above that, may be made to sound when the lower C is struck, because each of these strings is so tuned that its fundamental note has the same vibration rate as one of the overtones of the lower C, to which it responds by sympathetic resonance. A note sung near the piano may, in the same way, be more or less completely analyzed into its component tones.

The organ of hearing certainly has some such power of musical analysis, for some cultivated ears are not only able to follow a special instrument in a playing orchestra, but can even distinguish the overtones in the notes produced by it.

Inharmonic Overtones.—All overtones thus far considered are produced by vibrations which are simple multiples of the rate of the fundamental tone. Thus, the vibration rates of a series of upper partials may be two, three, four, five, etc., times that of the fundamental, or the vibration rate of the upper partials may be represented by the series of odd or even numbers, as the case may be. Such vibrations do not interfere with one another or with the fundamental tone, and their union produces on the ear an agreeable effect which gives them their name of *harmonics*. Harmonic upper partials are, according to Helmholtz, particularly characteristic of stretched strings and narrow organ pipes. But most elastic bodies when caused to vibrate give rise also to partial tones which are not exact multiples of the fundamental, and which may be termed *inharmonic* upper partials. The high-pitched jingle heard when a tuning fork is first struck represents the inharmonic upper partials of the fork. Stretched membranes have a great number of such inharmonic overtones, a fact which is of great importance in the function of the tympanic membrane. Inharmonic upper partials, as might be expected, rapidly die out in a note of which they form a part, because the vibrations causing them are antagonized by one another and by the stronger harmonic vibrations. For this reason the development of a well-marked fundamental tone is repressed in structures (like the tympanic membrane) which easily produce inharmonic overtones.

Interference of Sound. Beats.—Any source of sound, as a tuning fork, may be imagined as sending out from itself a series of waves of alternate condensation and rarefaction (see Fig. 385). If a second tuning fork, having the same pitch, is brought near the first, the motion imparted to the air particles will be a resultant of the two forces. If the forks vibrate in such order that the condensation or rarefaction produced by each simultaneously engages the same air particles, each of these conditions will become more intense and the sound will be *louder*. The forks are then said to vibrate in the same phase. But if one fork in its movement precedes or follows the other by *one-half* a vibration, then the phases of condensation from one tuning-fork correspond with those of rarefaction from the other, and the result is *silence*. A very important outcome of this principle of interference is manifested when two tones slightly different in pitch are sounded together. Let a prong of one of two vibrating tuning forks be loaded with wax; its vibrations will thereby be made slower and its pitch lowered. Though the forks may start vibrating in the same phase, the vibrations of one fork will outpace those of the other until a phase of condensation of the first will correspond to a phase of rarefaction of the second, and the result will

be perfect or comparative silence. The unequal rate of vibration continuing, like phases will again fall together and the sound will become louder than from either fork alone (Fig. 392). An alternate augmentation and diminution in the intensity of the sound is the result. These sound pulses are known as *beats*, and they are the cause of all discord in music. When two notes not included in a perfect chord are sounded on the piano, beats are

FIG. 392.—The Two Broken Lines Represent Air Waves of Slightly Different Vibration Rates. The solid line represents the "beats" or variations in sound intensity produced by the algebraic addition of the first two.

heard not only from the interference of the fundamental tones, but of the upper partials as well. It is the absence of beats in tones that should be in harmony, as those of the major chord, that determines the instrument to be in tune. When two tones produce beats, the number of beats in a given time is equal to the difference between the number of vibrations involved in the two tones in the same time. For example, a tone produced by 256 vibrations in a second sounded with one of 228 vibrations would give 28 beats in a second. It is evident that the frequency of beats may be increased either by increasing the interval between the tones or by striking tones of the same interval in a higher part of the scale. Beats which are not too frequent—from four to six in a second—have important musical value; but when they number 30 or 40 in a second they become exceedingly disagreeable, irritating the ear in a manner analogous to the effect of a flickering light on the eye. When sufficiently near together the beats no longer produce an intermittent sensation.

The number of beats required to result in this fusion increases as we ascend the musical scale, varying from 16 beats at C of 64 vibrations a second to 136 beats at c''' of 1,024 vibrations.

Harmony and Discord.—Tones are *concordant* or *harmonic* when they produce no beats on being sounded together; they are *discordant* when beats are produced, and the painful sense of dissonance increases in intensity up to about 33 beats per second. Perfect concord is obtained by blending tones whose vibrations are to one another as small whole numbers.

Thus, in the major chord C E G C the vibration numbers are 132, 165, 198, 264, their ratios are 4, 5, 6, 8.

If tones the ratio of whose vibration rates can be represented only by large whole numbers are combined, a discord is formed, for the reason that their upper partials interfere with one another and cause beats; there is no especial virtue in the small integer.*

Thus in the discord C D E the vibration numbers are 132, 148.5, 165, which are not reducible to small whole numbers.†

Resultant Tones.—When two powerful tones of different pitch are sounded together there may be heard in addition a third tone of much lower pitch than either. This is a *resultant* of the two primary tones and has been called a *difference tone*, because its pitch corresponds to a vibration rate equal to the difference of rates of the two primary tones. "Difference tones," though having the same numerical relations as "beats," are not to be confused with the latter. As two tones may generate a third which represents the difference between their vibrations, so, it was predicted and demonstrated by Helmholtz, they may give rise to *summation tones* whose pitch is determined by the *sum* of the vibrations of the primary tones. The vast complexity of the system of aërial waves to whose impress and analysis the ear is sensitive and capable, is well expressed by Tyndall:‡ "In the music of an orchestra, not only have we the fundamental tones of every pipe and of every string, but we have the overtones of each, sometimes audible as far as the sixteenth in the series. We have also resultant tones; both difference tones and summation tones; all trembling through the same air, all knocking at the self-same tympanic membrane. We have fundamental tone interfering with fundamental tone, overtone with overtone, resultant tone with resultant tone. And, besides this, we have the members of each class interfering with the members of every other class. The imagination retires baffled from any attempt to realize the physical condition of the atmosphere through which these sounds are passing."

(Out of the wealth of literature upon the physics of sound, mention may be confined to the work of Helmholtz: "Die Tonempfundungen," translated by Ellis, "Sensations of Tone," etc., which covers the field of physiological acoustics. Also, the lectures of Tyndall on "Sound," Appleton, 1877, are full of clear beauty on the physical side.)

ANATOMY AND PHYSIOLOGY OF THE EAR.

(Detailed description of the structure of the various parts of the ear may be found under appropriate captions. In this section anatomy and histology will receive as little attention as is consistent with clear exposition of functions.)

The *organ of hearing* is usually described as consisting of the following divisions: 1. *The external ear*, composed of the *pinna* or *auricle* and the *external auditory meatus*. 2. The *middle ear*, including, with its contents, the communicating Eustachian tube and the tympanic membrane. 3. The *internal ear* or *labyrinth*, including the vestibule, cochlea, and semicircular canals, with their corresponding membranous contents and the *ductus endolymphaticus*.

The *pinna or auricle* (Fig. 393) has less functional importance in man than in some of the lower mammals, as the deer, in which its trumpet shape is especially adapted for the collection of waves of sound. The extreme mobility of the auricle in such animals must make it of use in locating sounds, a function important to the preservation of its life from enemies. Even the human auricle, and especially the *concha*, must serve an important use in the collection of sound waves.

The *external auditory meatus or canal* (Fig. 393) serves the purpose of conveying with undiminished intensity

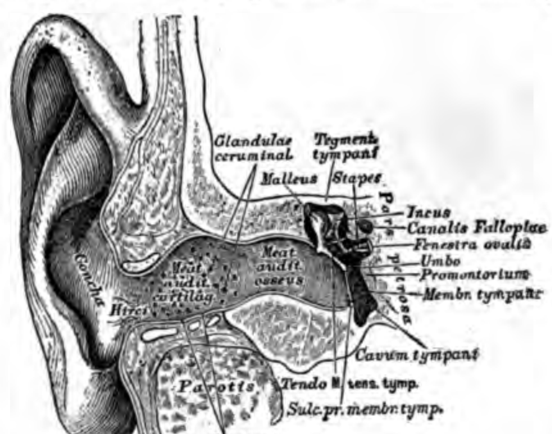


FIG. 393.—Vertical Section through Right External Auditory Canal and Tympanic Cavity. (After Heitzmann.)

the sound collected by the auricle to the tympanic membrane, while allowing this structure to be buried at a safe distance from the surface. Sound waves produced in the open air radiate in all directions and rapidly diminish in intensity (the decline in intensity is proportional to the square of the distance traversed). When sound is prevented from radiating, as when one whispers

* Tyndall: "Sound." † Waller: "Human Physiology," 1891. ‡ Tyndall: "Sound," 1872, p. 381.

into the open end of a tube, it is conducted for extraordinary distances. This is the principle on which the effectiveness of the stethoscope depends. The relations of the parts of the human external ear, the *tragus* and *antitragus*, the oblique direction of the meatus and the bend in its course, are admirably adapted for the protection of the tympanic membrane from external violence.

The external auditory meatus acts as a resonator for tones in unison with its own fundamental, whose pitch corresponds to a vibration rate of about three thousand per second. The shrill intensity possessed by certain tones near the upper limit of the musical scale, as the chirp of a cricket, is due to the sympathetic resonance of the auditory canal (Helmholtz).

The *middle ear or tympanum* (Figs. 393, 401) is an air-holding cavity of irregular shape in the petrous bone, and it is broader behind and above than it is below and in front. Posteriorly it is in open communication with the complex system of air cavities in the mastoid bone known as the *mastoid antrum* and the *mastoid cells*. A considerable portion of the cavity lies above the level of the tympanic membrane and is known as the *attic*. It is separated from the brain cavity by a thin plate of bone (*tegmentum tympani*, Fig. 393). It is easy to see how

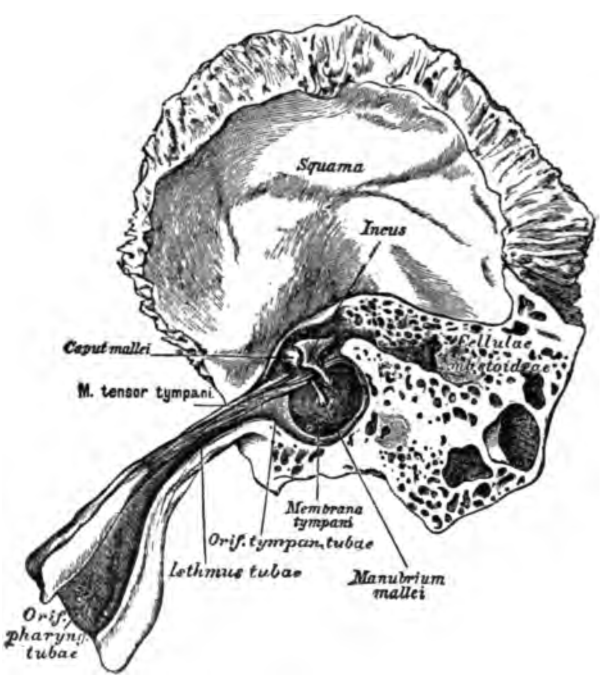


Fig. 394.—The Membrana Tympani and the Eustachian Tube, as Seen from Within. (After Heitzmann.)

suppurative inflammation of the middle ear not only may invade the mastoid cells but, by absorption of the thin roof of the cavity, and in other ways, may make *otitis media* the commonest source of pyogenic affections of the brain.* Anteriorly the tympanum is continuous with the pharynx through the Eustachian tube (Fig. 394). The inner wall of the cavity is formed chiefly by part of the bony envelope of the internal ear. The surface of the inner wall is pierced by two apertures, the *fenestra ovalis*, or oval window, and the *fenestra rotunda*, or round window, leading into separate divisions of the cavity of the bony labyrinth.

In life each fenestra is covered by a thin sheet of membrane, and the foot of the *stapes* (see below) is fastened by a ligamentous fringe in the oval window. The cavity of the tympanum is lined by mucous membrane continuous with that of the Eustachian tube and the pharynx, and the membrane, like that of the Eustachian

Fig. 395.—The Right Membrana Tympani as Seen from Without, After the Removal of a Part of the Osseous External Auditory Canal. (After Heitzmann.)

tube, is ciliated except over the surfaces of the ossicles and the tympanic membrane.

The *tympanic membrane or drum skin* (Figs. 393–397), separates the tympanic cavity from the auditory canal. It is a somewhat oval disc whose longer axis is directed from behind and above downward and forward, and whose length is about 9 mm. The membrane is inserted obliquely to the axis of the meatus, so that the floor of the latter is longer than its roof. The membrane varies considerably in its physical characters in disease, but normally it is semitransparent and of a pearly lustre to otoscopic vision (Figs. 396, 397). It is composed of an outer layer of thin skin, an inner layer of mucous membrane, with a coat of chiefly fibrous tissue between. The greater number of the fibres of this middle layer (*membrana propria*) radiate from near the centre to the periphery of the membrane; but there are also circular fibres of elastic tissue which are most numerous in a ring near the attached margin of the membrane. The surface of the drum skin is not flat, but is funnel-shaped with the apex of the funnel pointing inward, a position determined by the attachment of the handle of the malleus. Moreover, the radial lines of the membrane are not straight, but are slightly curved with the convexity outward, this shape being partly due to the tension of the circular elastic fibres. A small segment in the upper part of the membrane, *membrana flaccida*, or *Shrapnell's membrane*, lacks the tenseness of the rest of the structure. When light is thrown upon the normal tympanic membrane, a bright reflection (known as the pyramid of light) is seen in its lower anterior quadrant. The apex of the bright triangle is at the tip of the manubrium, and its base is on or near the periphery of the membrane.

Fig. 396.—Normal Membrana Tympani (right side). After Jacobson.)

Auditory Ossicles.—The vibrations of the tympanic membrane are transferred to the *fenestra ovalis* of the labyrinth by a chain of three little bones: the *malleus* (hammer), *incus* (anvil), and *stapes* (stirrup), the so-called *auditory ossicles* (Figs. 398, 399). The *malleus* is 18 to 19 mm. long; it has a rounded head grooved on one side for articulation with the incus, a short neck and a long

Fig. 397.—Normal Membrana Tympani (left side). (After Jacobson.)

* Macewen, "Pyogenic Diseases of the Brain and Spinal Cord," 1893.

handle or *manubrium*, which is inserted in the tissue of the tympanic membrane from a point on its upper periphery to a little below its centre. The *processus brevis* of the malleus is a low conical projection which rises from the top of the manubrium and presses directly against that segment of the tympanic membrane which lies immediately below the *membrana flaccida*, or membrana von vibrans. These parts can usually be seen on inspection with the ear speculum (Figs. 10, 13, 14). The *processus gracilis* or *processus Folianus*, long and slender, arises from an eminence just below the neck of the malleus, and, passing forward and outward, is inserted in the Glaserian fissure in the wall of the tympanum. The malleus is held in position partly by ligaments. The *superior* or *suspensory ligament* passes downward and outward from the roof of the tympanum to be inserted into the head of the malleus. The main portion of the *anterior ligament* (Fig. 400) is attached to the neck of the malleus just above the *processus gracilis*; it embraces the latter, and, passing forward, finds its origin in the anterior wall of the tympanum and in the Glaserian fissure. Another division of this ligament, the *external ligament*, arises and is attached more externally than that just described. The ligaments of the malleus serve to keep its head in position (Figs. 400, 401). The external ligament being attached above the axis of rotation of the hammer, prevents the head of this bone from moving too far inward, and the manubrium from being pushed too far outward. The superior ligament, owing to its oblique course, restrains the head of the hammer from moving too far outward.

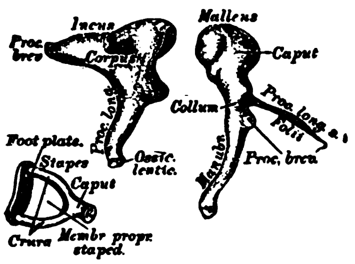


FIG. 398.—The Three Ossicles. (After Heitzmann).

The *incus*, *ambos*, or anvil bone, is shaped somewhat like a bicuspid tooth. Its body is hollowed on the surface and covered with cartilage for articulation with the head of the malleus. It has two processes, a *long* and a *short*, which project at right angles to each other. Their respective lengths are about 4 and 3 mm. When in natural position, the long process descends nearly parallel with the manubrium, but it has less than three-fourths the length of the latter. The free end of the long process is turned sharply inward at right angles, and terminates in a rounded projection, the *os orbiculare* or *lenticulare*, which is provided with cartilage for articulation with the head of the *stapes*. The short process is conical in shape and is thicker than the long process. It has a horizontal position, and is attached by a thick ligament to the posterior wall of the tympanum.

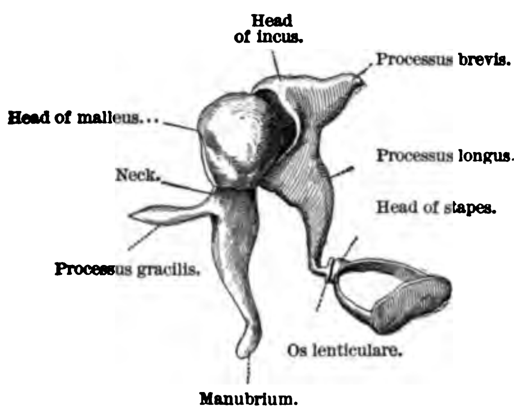


FIG. 399.—The Ossicles in Their Normal Relations. (After Henle.)

The *stapes* articulates with the end of the long process of the incus; its plane is horizontal and about at right angles to that process. It measures about 3 to 4 mm. in length by about 2.5 in breadth. The base of the stirrup bone is set in the *fenestra ovalis*, an aperture measuring about 3 by 1.5 mm., and is held in position by a narrow membrane made up of radial fibres of connective tissue (Fig. 402). When in position, the innerface of the base of the stapes is covered with lymphatic endothelium and is washed by the perilymph of the internal ear; the outer face, like the other ossicles and the wall of the tympanum, is covered by thin mucous membrane.

Movements of the Ossicles.—The *malleus-incus* articulation is so arranged that with outward movements of the manubrium the head of the malleus glides freely in the joint; but the lower margins of the articulating surfaces project in such a way that the prominences catch upon each other and interlock when the manubrium is moved inward. Thus, in inward movements of the tympanic membrane and its attached manubrium, the malleus and incus move together like one rigid piece of bone, the motions of the manubrium and of the long process of the incus being parallel. In the outward movements the locking teeth or projections are probably, under ordinary conditions, still kept in apposition through the elastic reaction of the ligament and the stapedial attachment of the incus. Should, however, the tympanic membrane be forced unduly outward, as by increase of pressure within the tympanum or rarefaction of the air in the auditory meatus, the incus only follows the malleus for a certain distance, the latter completing its motion by gliding in the joint. There is thus no danger of the stapes being torn out of the oval window. Of the malleus-incus articulation Helmholtz says: "In its action it may be compared with the joints of the well-known Bréguet watch keys, which have rows of interlocking teeth, offering scarcely any resistance to revolution in one direction, but allowing no revolution whatever in the other." The hammer and the anvil, suspended by their ligaments, move freely about an axis one end of which is found at the origin of the anterior part of the anterior ligament of the malleus, and the other end in the origin of the ligament which is continuous with the short process of the incus (Fig. 400).

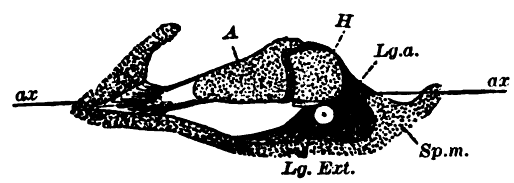


FIG. 400.—A Nearly Horizontal Section through the Tympanum, Including the Malleus-Incus Articulation. *H*, Head of hammer, inner surface; *A*, anvil or incus, whose short process is held by ligaments in a bony niche: *Sp.m.*, spina major of tympanic wall; *Lg.a.*, anterior ligament; *Lg. Ext.*, external ligament. The line *ax-ax* represents the axis of rotation of the two ossicles. (After Hensen.)

In inward motions of the tympanic membrane (and probably under ordinary conditions in outward motions as well), the ossicles move like a single bone about the axis of suspension. The three bones may be likened, then, to a single rigid lever of peculiar form. The power is applied to this lever at the tip of the manubrium, the effect is produced at the footplate of the stapes. Observation shows that the fulcrum is found at the end of the short process of the incus. From the latter point the distance measured to the *umbo* or tip of the manubrium is about one and one-half times the distance from the fulcrum to the end of the long process of the incus. Therefore, motions imparted to the stapes can have but two-thirds the amplitude of those arising at the umbo; but, according to the principles of the lever, the former movements have one and one-half times the force of the

latter. It will be noticed that a large proportion of the mass of both anvil and hammer is found above their axis of rotation; this upper portion acts as a counterpoise to the parts below which are directly concerned in the lever action. The bony lever being thus balanced, it is less difficult to understand its known sensitiveness to impulses that are inconceivably weak. The tense tympanic membrane, by reason of its funnel shape, resists strong inward compression; hence the stapes is prevented from being pressed too far inward. The maximum amplitude of motion of the end of the long process of the incus is very small, being only about $\frac{1}{18}$ to $\frac{1}{14}$ mm., while that of the centre of the tympanic membrane is about $\frac{1}{18}$ to $\frac{1}{8}$ mm.

The great rapidity of aërial vibrations to which the chain of ossicles can respond suggests that it conducts the sound pulses as molecular or longitudinal vibrations, as a rigid rod of wood transmits the tick of a watch. But Helmholtz has shown reasons for believing that the functional movements of the ear bones is molar, that they oscillate as a whole, the chain moving in a body with each impulse. It is open to suspicion that the upper limit of the scale of pitch may be determined by the superior rate of vibration to which the chain of bones is capable of responding. The sole purpose of this apparatus of the middle ear is to transmit exactly the variations of pressure in the air of the external auditory meatus to the perilymph which bathes the foot of the stapes; in other words, to convert air waves into a similar series of water waves. As put by Helmholtz: "The mechanical problem which the apparatus within the drum of the ear had to solve was to transform a motion of great amplitude and little force, such as impinges on the drum-skin, into a motion of small amplitude and great force, such as had to be communicated to the fluid in the labyrinth." The adaptation of the apparatus of the middle ear to this end is worthy of careful consideration. In the first place, it will be noticed that the area of the fenestra ovalis which receives the impulses of the stapes is but a small fraction of the surface of the tympanic membrane on which the air waves impinge, the latter area being some fifteen to twenty times greater than the former, so that the energy of air motion is, in a fashion, concentrated. In the second place, as previously observed, the lever mechanism of the auditory ossicles is such that the movements of the end of the long process of the incus have two-thirds the amplitude of those of the tip of the manubrium, but about one and one-half times their force. It should also be noticed that the membrane fastening the foot of the stapes in the fenestra is somewhat less tense on the upper side, so that the top of the oval footpiece has a freer motion than the bottom, and, as the end of the incus process moves somewhat upward and inward, the head of the stirrup rises slightly with inward motions. In other words, the stapes itself forms an independent lever, of which the long arm is the height of the stirrup and the short arm less than the breadth of its footpiece, by which the motion imparted by the incus is further reduced in amplitude but increased in power. In the third place, it has been demonstrated by Helmholtz that the shape of the tympanic membrane peculiarly adapts it for transforming weak movements of wide amplitude into strong ones of small compass. For this membrane is not a simple funnel depressed inwardly, but the radii are slightly curved with the convexity outward, a shape chiefly due, it is said, to the tension of the elastic circular fibres of the membrane on its inner face, these being most numerous toward the circumference. Air waves beating upon this convexity flatten the curve somewhat, and their whole energy must be concentrated, with increased intensity, but loss of motion, near the central point of the membrane. The same effect is illustrated by the fact that when a string or rope is stretched horizontally between two points, no matter how tightly, it always sags in the middle; the weight of the cord, however slight, drags it down in a curve, and produces a corresponding traction on the points of support.

Special Properties of the Tympanic Membrane.—It is evident that any marked tendency of the transmitting apparatus of the middle ear to vibrate at a particular rate—that is, possession by it of a strong fundamental tone—would render impossible the conduction of aërial pulses in their actual proportion of intensity. Membranes have fundamental tones (see p. 613) whose pitch is determined by their area, thickness, and tension, but they differ from rods, strings, etc., in being less strictly confined to a single fundamental tone in their vibration. The tympanic membrane is peculiar in that it can hardly be said to have a definite fundamental tone. This is prevented probably both by reason of its structure and the peculiar form of its surface, and also because its oscillations are damped by the pressure of the malleus held in position by the other mechanisms of the tympanum.

One important purpose subserved by the tympanic membrane is no doubt to guard from injury the delicate membranes of the fenestræ and other contents of the middle ear. The astonishing freedom of the normal membrane from foreign particles is probably due to a radial movement of its surface epithelium in the course of cellular renewal.

When the tympanic membrane is perforated or is even wholly removed, without destructive inflammatory changes in the middle ear, sounds are still heard, though usually with diminished loudness. An artificial drum inserted in the meatus occasionally improves hearing in the absence of the normal membrane, or when the transmitting mechanism is abnormally relaxed. It is said that it should be placed in contact with the malleus, and its mode of action seems to be to bring aërial vibrations to bear effectively upon the ossicles. A small wad of cotton has been employed with the same result.

When the tympanic membrane is absent, air waves beat directly upon the membranes of the fenestræ, and certain sounds may then be heard with increased loudness. But in the absence of the elaborate arrangement described above for abolishing sympathetic vibration of the sound-conducting mechanism, it is probable that the fenestral coverings are crude and inaccurate interpreters of the sounds beating upon them. Thus, a musician who had suffered loss of his tympanic membranes was no longer able to play his violin, probably because sounds of different pitch ceased to be perceived in their true relations of loudness (Dr. E. C. Rivers).

Hearing by Bone Conduction.—Just as the sound of a watch or tuning fork may be conducted through a wooden rod, so molecular vibrations may pass to the auditory apparatus through the bones of the skull. Such movements probably have the nature of the longitudinal vibrations discussed in a previous section (p. 611). If the stem of a sounding tuning fork be touched to the skull or held between the teeth the tone will be plainly heard, and the sound becomes louder when the ears are stopped. If the fork be held between the teeth until the sound dies away, the tone reappears upon closing one of the auditory canals and on the same side as the closure. A fork which has become silent to air conduction may still be heard if held between the teeth; and when the sound again dies away, it returns when the stem of the fork is inserted into the meatus.* Hearing by bone conduction occurs in the absence of the tympanic membranes, and even when the membranes covering the fenestræ of the internal ear are so altered by disease as to be ill adapted to transmit vibrations. Such vibrations are, probably, transmitted directly through the bony labyrinth to its contained fluid, though in the presence of the normal fenestral coverings and of the tympanic membrane the vibrations are, without doubt, taken up and transmitted by these structures. Closing the ears would then reflect and intensify the sound.

In deafness due to middle-ear trouble sound can still be plainly heard by bone conduction. The *audiphone* is essentially a sheet of some elastic material, as hard rubber, easily set into sympathetic vibration, which is held

* Hensen: Hermann's Hdb. d. Physiologie, Bd. iii., Th. 2.

against the teeth to which it transmits vibrations that it has taken up like a sounding board.

In deafness due to disease of the internal ear vibrations conducted through the bones of the skull make no auditory impression. According to Egger,* even when there is deafness to skull vibrations, a tuning fork may still be heard and pitch recognized when it is applied to the bones of the extremities (olecranon, tibia). As this power fails when the part is made anæmic by Esmarch's bandage, the author ascribes the sensation not to bone conduction, but to irritation of the auditory centres by way of the nerves of common sensation.

Eustachian Tube.—Any steady inequality of air pressure on the two sides of the tympanic membrane would evidently more or less interfere with its functional movements. As air is probably continuously absorbed from the tympanum and as external barometric pressure is ever varying, the drum of the ear needs some arrangement for the maintenance of an equilibrium of air pressure on the two sides of the tympanic membrane. Such a mechanism is found in the *Eustachian Tube*, a somewhat trumpet-shaped canal which, beginning in the lower, anterior wall of the tympanum, runs downward, forward, and inward, and terminates in a slit in the side of the upper part of the pharynx (Fig. 394). The Eustachian tube is lined, like the walls of the tympanum, with ciliated epithelium, the cilia working in such a way as to convey into the pharnyx such secretions as may be poured into the middle ear, as well as the foreign matter that may enter the canal from the pharynx. A consideration of the ordinary mode of infection of the middle ear from the pharnyx suggests how important a rôle must be borne by the ciliated epithelium in the preservation of health.

The pharyngeal opening of the Eustachian tube is probably usually closed, but may be made to open by considerable increase of air pressure within the pharynx, as may be produced by closing the nose and mouth and either forcing air into the pharynx by strong expiratory movement or rarefying it by suction. In the former case air pressure within the middle ear is increased, in the latter it is diminished. When air is thus made to enter or leave the tympanum a sensation of a sudden snap and a dull crackling noise in the ear are experienced. The lower end of the tube is normally opened during the act of swallowing, and it is at this moment that the intra- and extra-tympanic pressures are equalized. The well-known method of Politzer for inflation of the middle ear consists in forcing air into one nostril during the act of swallowing, while the other nostril and the mouth are closed.

Muscles of the Middle Ear.—There are two intrinsic muscles of the middle ear which serve to adjust the tension of its transmitting mechanism. Roughly speaking, they are antagonistic in action. The *tensor tympani* muscle is lodged within a groove which is just above and about parallel with the Eustachian tube (Fig. 394). It terminates externally in a long tendon which bends nearly at right angles round the outer edge of the groove and is inserted into the handle of the malleus near the neck. Contraction of the tensor tympani thus pulls the tympanic membrane inward, renders it more tense, and somewhat dampens its vibrations (Fig. 401). At the same time the toothed processes of the incus and malleus are brought closely together so that there can be no loss of motion in vibration of the ossicles, and the stapes is driven further into the oval window, increasing tension within the labyrinth. Opinion is somewhat divided as to the conditions of functional activity of the tensor tympani. The normal tone of the muscle probably gives it some constant tensor effect. It is said that the relaxed tympanic membrane, particularly after section of the tensor tympani muscle in lower animals, is thrown into sympathetic vibration with comparative ease, and is in this condition best adapted to respond to weak aërial impulses and to the periodic waves of musical notes. When the membrane is tense its vibrations are more or less damped and it is then best fitted to transmit with distinctness the irregular vibrations of noises and consonantal sounds. It would follow that the action of the muscle facilitates distinct appreciation of speech while it diminishes acuteness of hearing. According to Hensen * the tensor tympani muscle is reflexly excited to contract by the initial waves of a sound, resulting in a closer interlocking of malleus and incus, thereby preventing loss of motion in subsequent vibrations. But Osterman † has given reason for believing that the muscle is chiefly a protective mechanism called into play only or mainly by

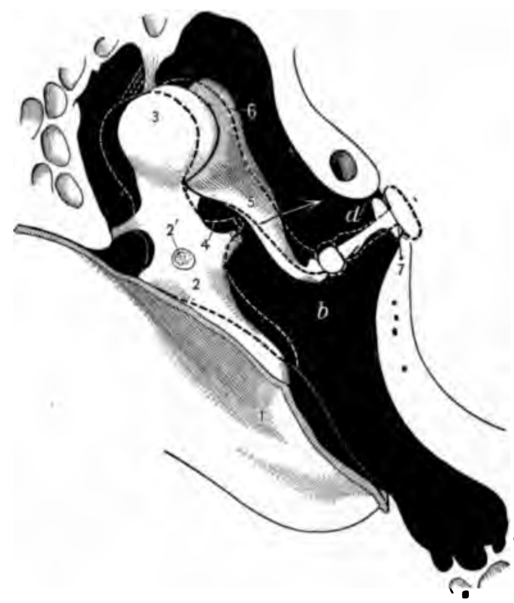


FIG. 401.—Diagram Representing the Mode of Displacement of the Ossicles under the Influence of the Contraction of the Tensor Tympani Muscles. (After Testut.) *a*, External auditory canal; *b*, tympanic cavity; *c*, vestibule of the inner ear; *d*, fenestra ovalis; 1, membrana tympani; 2, manubrium mallei; 2′, section of the long process of the malleus; 3, head of the malleus; 4, insertion of the tendon of the tensor tympani muscle; 5, vertical or long process of the incus; 6, head of this ossicle; 7, the stapes. The dotted lines indicate the positions which the ossicles and tympanic membrane will assume when the tensor tympani muscle contracts; the arrow shows the direction of this movement.

very loud and painful noises. Its action prevents oscillations of the tympanic membrane which would otherwise be of so great amplitude as to damage the ear.

The *stapedius* is a small muscle embedded in the inner wall of the tympanum near the fenestra ovalis. Its tendon, passing forward, is inserted into the neck of the stapes. Contraction of the muscle would have the effect of pressing the hinder part of the foot of the stapes either against the edge of the oval window or farther into the opening, and of withdrawing the forward part from it (Fig. 402). The muscle may therefore be considered to diminish pressure within the labyrinth, causing the membrane of the round window to be drawn inward. Its action in these respects is the opposite of that of the tensor tympani. It is said that the stapedius is controlled by the facial and the tensor tympani by the fifth nerve.

A bundle of fibres passing backward from the anterior part of the tympanum to be inserted into the malleus just above the root of the processus gracilis has been described as the *laxator tympani muscle*. It will receive no further notice since Helmholtz and others consider it to be merely a ligamentous support for the malleus.

The Internal Ear or Labyrinth.—This is the seat of

* Egger, M.: Compt. rend. de la soc. d. biol., 1898, 815; Jahresbericht d. Physiologie, 1899, S. 98.

* Hensen: Hermann's Hdb. d. Physiologie, Bd. iii., 1880.
† Osterman: Arch. f. Anat. u. Physiologie, 1898, s. 75.

the sensory organ of hearing. It is composed of a complicated system of membranous tubes and sacs, the *membranous labyrinth*, in which terminate at particular points bundles of filaments of the auditory nerve. The mem-

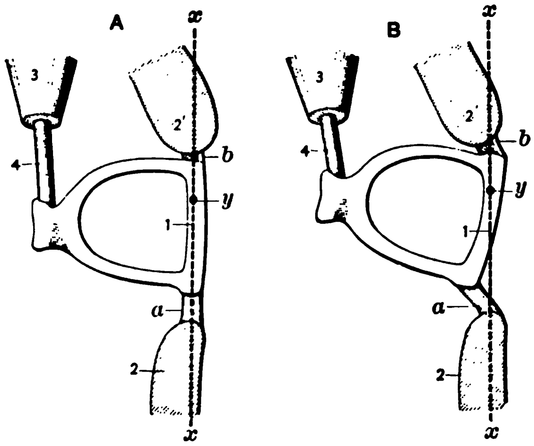


FIG. 402.—Diagram Showing How the Stapes is Displaced under the Influence of the Contraction of the Stapedius Muscle. (After Testut.) *A*, Stapes in repose; *B*, stapes after the stapedius muscle has contracted. 1, Base or footplate of the stapes; 2, anterior margin of the fenestra ovalis; 2′, posterior margin of the same; 3, pyramidal process, giving exit to the tendon (4) of the stapedius muscle; *a*, anterior portion of the annular ligament; *b*, posterior and shorter portion of the same ligament; *xx*, antero-posterior diameter of the fenestra ovalis, passing through the footplate of the stapes in its two positions—*A*, when in repose, *B*, after the contraction of the stapedius muscle; *y*, the point through which the vertical line that represents the axis of rotation of the stapes passes.

branous labyrinth is contained within a chamber, the *bony labyrinth*, hollowed in the petrous bone (Figs. 403–406). The osseous tissue immediately surrounding the labyrinthine cavity is very dense and with care may be separated from the bone of looser texture about it. The cavity of the bony labyrinth (Figs. 403, 404) consists of

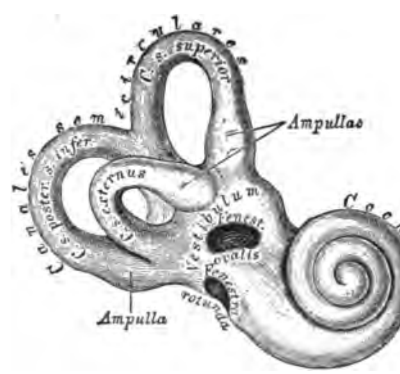


FIG. 403.—The Bony Shell of the Labyrinth. (After Heitzmann.) ?.

a median part, the *vestibule*, which is prolonged posteriorly in the system of *semicircular canals* and anteriorly in the *cochlea*. The vestibule is a space which measures in man about one-fifth of an inch in diameter, and it is perforated on its outer wall by the oval opening known as the *fenestra ovalis*. The semicircular canals are three tubes of circular section, known respectively as the anterior or superior, the posterior, and the external or horizontal semicircular canal. Their planes are about at right angles to one another, so that they occupy the three possible dimensions of space. Each canal is dilated at one extremity into a globular cavity which is known as the *ampulla*. The anterior and posterior canals unite near the ends not provided with ampullæ, and they enter the vestibule as a common tube. Anteriorly the vestibule is continued as a tube which is coiled upon itself two and one-half times, and which, from its resemblance to the shell of a snail, is known as the *cochlea*. The osseous cochlea (Fig. 405) may be conceived as formed by a bony tube coiled about a bony central pillar, the *modiolus*, which is of spongy texture and diminishes in diameter from the base to the apex of the cochlea. From the modiolus a bony shelf, the *lamina spiralis*, stretches into the cavity of the tube, incompletely dividing it into two tubular chambers, and winds round the central pillar like a spiral staircase. The separation of the spaces on either side of the *lamina spiralis* is rendered complete by membranous structures to be considered later. The tubular area on that side of the lamina spiralis which faces the apex of the cochlea is in free communication with the vestibule and is known as the *scala vestibuli*. The part of the canal which is on the opposite side of the lamina spiralis, facing the base of the cochlea, is known as the *scala tympani*, because it comes into relation with the tympanum at the fenestra rotunda (Figs.

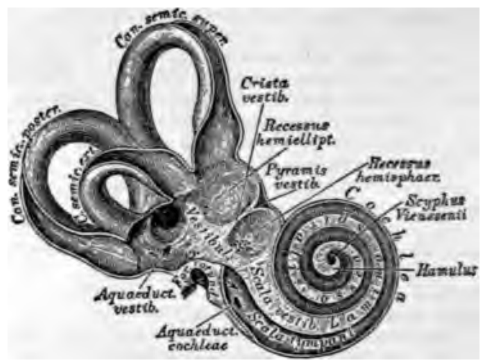


FIG. 404.—The Bony Labyrinth, Open toward the Front. (After Heitzmann.) ?.

405–408). In the upright position of the head the axis of the modiolus is nearly horizontal, pointing from base to apex, outward and slightly downward and forward, the base of the cochlea being formed by the inner surface of the petrous bone. Contained within the cavity of the bony labyrinth, and on the whole parallel with its walls, is the *membranous labyrinth*, in which are found the

FIG. 405.—The Cochlea, Opened in a Direction at Right Angles to the Axis of the Pyramidal Portion of the Temporal Bone. (After Heitzmann.) ?.

essential structures of the organ of hearing (Figs. 406–408). The membranous labyrinth is filled with a somewhat watery, mucin-holding fluid, the *endolymph*, while a similar fluid, the *perilymph*, fills the space between the membranous labyrinth and the bony walls outside it.

The perilymphatic space is lined with lymphatic epithelium and is in communication, along the sheath of the auditory nerve, with the subdural and subarachnoid lymph areas of the brain. Numerous sheets and bars of connective tissue reach from the wall of the bony to that of the membranous labyrinth and help support the latter.

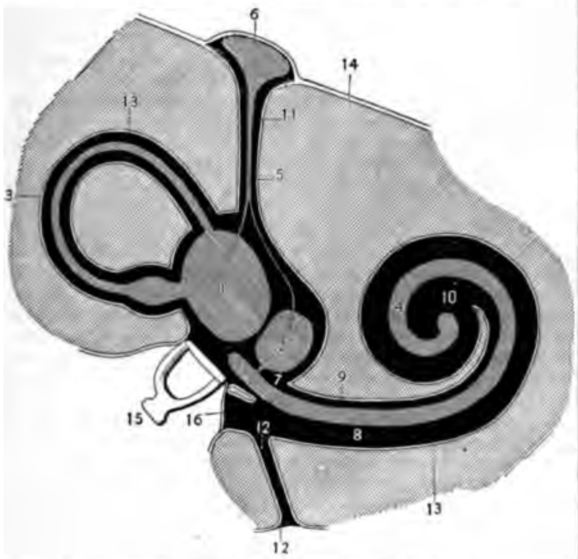


FIG. 406.—Diagram Indicating the Peri- and Endo-lymphatic Spaces of the Inner Ear. (After Testut.) The endolymphatic spaces are represented in gray, the perilymphatic in black. 1, Utriculus; 2, sacculus; 3, semicircular canals; 4, cochlear canal; 5, endolymphatic canal, with its two initial branches; 6, endolymphatic cul-de-sac; 7, canal of Hensen or canalis reuniens; 8, scala tympani; 9, scala vestibuli; 10, their point of union at the helicotrema; 11, aquæductus vestibuli; 12, aquæductus cochleæ; 13, periosteum; 14, dura mater; 15, stapes in the fenestra ovalis; 16, fenestra rotunda and secondary tympanic membrane.

That part of the membranous labyrinth which is contained within the bony vestibule is composed of two separate sacs which only indirectly communicate with each other (Figs. 406, 407). The posterior sac is larger and is known as the *utriculus* or *utricle*. From it spring the membranous semicircular canals. The smaller anterior sac is called the *sacculus* or *saccule*. The cavities of the utricle and saccule are indirectly continuous through two small tubes which arise from either sac and, uniting, form a single tube, the *ductus endolymphaticus*, which runs inward through a canal in the petrosal bone and ends blindly in a dilated, flattened extremity, the *saccus endolymphaticus*, which is supported between the layers of the *dura mater* within the cranial cavity. The plane separating the two vestibular sacs is perpendicular and opposite the fenestra ovalis (Fig. 406). The sacculus communicates by a narrow tube, the *canalis reuniens*, with that division of the membranous labyrinth which is contained within the bony cochlea and known as the *canalis* or *ductus cochlearis* (Fig. 406).

The *auditory nerve* consists of at least two divisions having separate origins and different distributions. One of these branches passes finally to the cochlea, and the other to the vestibule and semicircular canals. The nerve approaches the labyrinth by way of a canal known as the *meatus auditorius internus*, and on reaching the angle between the base of the cochlea and the vestibule, the cochlear branch passes to its destination, while of the remainder of the nerve a superior division is distributed to the utricle and to the ampullæ of the anterior and horizontal semicircular canals, and the inferior division supplies the saccule and ampulla of the posterior canal.

The inner wall of both utricle and saccule is elevated at a particular spot into a low eminence, the *macula acustica*, formed by development of the connective tissue of the membranous wall. In a similar way, the inner wall of each ampulla of the semicircular canals is developed in a ridge projecting into the cavity across its long axis and known as the *crista acustica*. Both *maculæ* and *cristæ* are covered by peculiarly modified columnar epithelial cells, called *auditory epithelium* because they receive the terminal twigs of the auditory nerves. The auditory cells are said to be of two kinds. One variety is cylindrical in shape and reaches only part way to the basilar membrane, the *hair cells;* the other, narrow and elongated, the supporting or *sustentacular cells*. From the free ends of the former there project long, stiff, hair-like processes, the *auditory hairs*, which are longer on the cells of the cristæ than on those of the maculæ. The auditory nerve filaments supplying this part of the labyrinth pass through the maculæ and cristæ and, breaking up into nodulated fibrils, encircle the bodies of the hair cells. Seated on the free surface of the macular epithelium is a fibrous mass which is said to be a normal structure and not, like a somewhat similar mass found covering the cristæ in post-mortem sections, a coagulum due to the method of preparation. Embedded in the membrane over the maculæ of both sacs are small crystals, *otoliths* or *otoconia*, composed chiefly of carbonate of lime. Otoliths are found at times also in the ampullæ and even in the perilymph space of the cochlea. In some fishes there are large masses of calcareous matter, otoliths, attached to the walls of the vestibular sacs.

The Membranous Cochlea.—By far the most complex structure of the ear is found in the cochlea. The membranous cochlea (Figs. 408, 409), sometimes known as the *canalis* or *ductus cochlearius*, is a tube of nearly triangular cross section. The base or outer side of this triangle is attached closely to the wall of the bony cochlea; the upper side, supposing the modiolus to be vertical with its apex above, is made of a thin sheet of cells known as the *membrane of Reissner;* the lower side is made up partly of the bony margin of the *lamina spiralis* and partly of a membrane radially striated, stretched across from the edge of the spiral lamina to the side wall of the cochlea; this is called the *basilar membrane* or *membrana basilaris* (Fig. 409).

The coiled tube of the osseous cochlea is thus divided longitudinally into three parallel tubes: the *scala vestibuli* and the *scala tympani* on either side of the lamina spiralis, and the *canalis cochlearis* between them, where the spiral lamina is wanting.

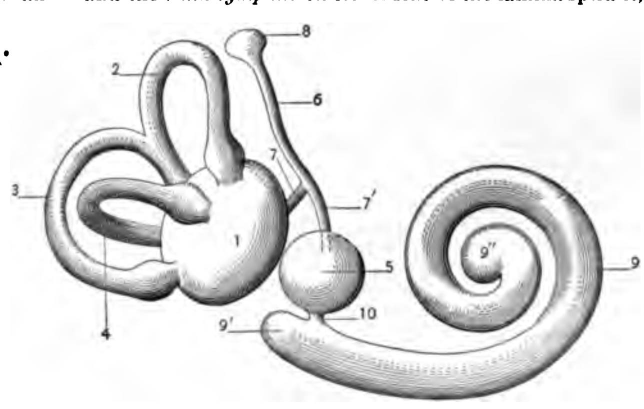


FIG. 407.—Membranous Labyrinth of the Right Side. (After Testut.) 1, Utriculus; 2, superior semicircular canal; 3, posterior semicircular canal; 4, external semicircular canal; 5, sacculus; 6, endolymphatic canal, *ductus endolymphaticus*, with (7 and 7') its parent canals; 8, its terminal cul-de-sac, *saccus endolymphaticus*; 9, cochlear canal, with (9') its vestibular cul-de-sac and (9") its terminal cul-de-sac; 10, canalis reuniens of Hensen.

The *canalis cochlearis* contains endolymph and is closed at each end, but its cavity communicates by way of the narrow *canalis reuniens* with that of the saccule. The

tubes or scalæ on either side of the membranous cochlea are perilymph spaces. The upper tube, when followed down to the base of the cochlea, is found to open freely into the cavity of the vestibule; hence its name of *scala*

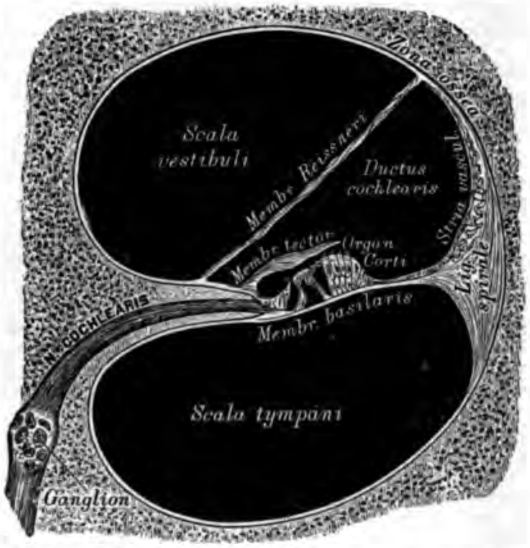


FIG. 408.—Semidiagrammatic Section of a Cochlear Whorl. (After Heitzmann.)

vestibuli. The lower tube ends blindly at the base of the cochlea, but, where this part bulges into the tympanum as the "promontory" of its inner wall, it is perforated by the aperture known as the *fenestra rotunda* whose proper membrane alone prevents the perilymph from escaping into the middle ear. This tube is therefore called the *scala tympani*. From its central position the membranous cochlear canal is sometimes known as the *scala media*.

As the spiral staircase formed by the osseous lamina spiralis and the membranous basilar membrane winds round the modiolus from the base to the apex or *cupola* of the cochlea, the radial width of the basilar membrane increases while that of the bony lamina decreases. In the basal whorl of the cochlea the width of the two is about equal, but near the cupola the lamina spiralis is nearly wanting. The radial width of the basilar membrane is said to vary from .36 mm. at the top of the cochlea to about .21 mm. near the bottom. The scala vestibuli and the scala tympani have no communication except through a small aperture under the cupola of the cochlea known as the *helicotrema*; this is bounded by the hook-like termination, the *hamulus* (Fig. 404), of the bony lamina spiralis, which forms the greater part of a ring completed by the pointed, blind extremity of the canalis cochlearis fastened above the hamulus to the cupola.

Transmission of Vibrations through the Labyrinth.—We have seen above (p. 613) that composite air waves differ from the single pendular vibrations of which they are made up by their form. That is, while in a single pendular vibration the motion of an oscillating air particle is similar, and its acceleration or retardation is uniform on each side of the point of rest, in the composite wave this is not so. The tympanic membrane must respond to all the variations in the sound pulses entering the meatus and transmit them with exactness, though with diminished amplitude and increased force, to the foot of the stapes. The end of the long process of the incus rises somewhat in its inward excursion, so that the head of the stapes is slightly raised at each impulse. The motion of the stapes in the fenestra ovalis is, therefore, not so much that of a piston in a cylinder as a *wobble* about an axis that runs parallel and near to the lower edge of the footplate.* As the maximum excursion of the incus-stapes articulation is only about $\frac{1}{14}$ mm., that of the foot of the stapes must be still further reduced and increased in power.

The fluid of the labyrinth being incompressible, any considerable inward movement of the stapes must be attended by provision for the outlet of the displaced fluid. Such a safety valve is found in the fenestra rotunda. Perilymph pressed away from the oval window may find a free vent by passing through the scala vestibuli toward the apex of the cochlea, through the helicotrema, backward by way of the scala tympani, at the basal end of which it finds the fenestra rotunda, and may cause its covering membrane to bulge into the tympanum. That such a transference of fluid in the direction from the oval to the round window can take place was demonstrated by Politzer, who inserted a glass tube in the fenestra rotunda and found that fluid in the tube took a higher level when strong air pressure was brought to bear on the outside of the tympanic membrane. It is hardly conceivable, however, that actual molar motion of perilymph through the helicotrema occurs with each oscillation of the foot of the stapes. The effect upon the membrane of the round window of a continuous musical note, for example, is probably to give it a fixed position midway between that resulting from the maximum and that resulting from the minimum displacement at the oval window. This action may be illustrated by a device sometimes used for the determination of the mean arterial blood pressure of an animal; the mercury manometer is constricted at one point to a narrow orifice which blocks the rapid oscillations of the heavy mercury, so that the difference in level of the fluid in the two limbs of the instrument is constant and represents the mean between the varying pressures. That the actual transfer of fluid from the scala vestibuli to the scala tympani is not necessary for the irritation of the nervous mechanism of the cochlea is indicated by audition through bone conduction, in which it seems that molecular vibrations may arouse the sense of sound by direct transmission through the osseous cochlea. We may look upon the action of the stapes as that of a hammer which applies sharp taps to the perilymph.

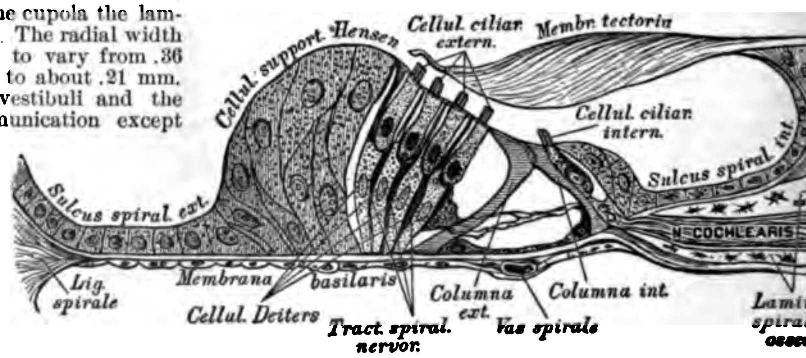


FIG. 409.—Semidiagrammatic Section of the Organ of Corti. (After Retzius, from Heitzmann's "Anatomie des Menschen.")

As the terminations of the auditory nerve are all within the closed and complex membranous labyrinth, vibrations of the perilymph, to have sensory effect, must be taken up by the wall of that structure. The sensory epithe-

* Henke, quoted by Hensen: Hermann's Hdb. der Physiologie, Bd. iii., Th. 2, S. 36.

lium of the saccule, utricle, and semicircular canals would seem to be impressed by vibrations proceeding directly from the oval window. Considering the minuteness of the canalis reuniens, it is not probable that irritation of the cochlear nerve depends upon vibrations reaching them through the endolymph of the saccule, but that it is achieved through motion imparted by the broad way of the scala vestibuli, the diminishing calibre of which toward the apex of the cochlea would seem adapted to the concentration of energy of vibration toward that point. The indirect tubular communication between the various chambers of the membranous labyrinth and with the cranial cavity through the *ductus endolymphaticus* and its dilated extremity afford evident provision for the equalization of pressure throughout the endolymph.

The Membranous Cochlea and the Organ of Corti.—The *ductus cochlearis* is somewhat triangular in cross section, its floor being composed, in the lower whorls of the cochlea, of the *basilar membrane* and the edge of the lamina spiralis (Fig. 408); but the latter component decreases as the apex is reached, so that both the relative and the absolute width of the basilar membrane increases as the cupola is approached (p. 622). The delicate *membrane of Reissner*, stretched from a line on the lamina spiralis somewhat back from its edge to the wall of the bony cochlea, separates the canalis cochlearis from the scala vestibuli, as the basilar membrane does from the scala tympani.

From the physiological standpoint interest is chiefly centred in the basilar membrane and the structures supported by it. The *basilar membrane* is a sheet of complex tissue tightly stretched between the edge of the lamina spiralis and the outer wall of the cochlea. The membrane is fibrillated and splits readily in a radial direction, and has been supposed to represent essentially a series of stiff elastic fibres more or less coherent in a cement substance (Fig. 409). Seated on the inner part of the basilar membrane is the peculiar structure known as the *organ of Corti* (Figs. 408, 409).

The *organ of Corti* has as its supporting framework a series of modified cuticular epithelial cells known as the *rods of Corti* (*Columnæ ext.* and *int.*, Fig. 409), which are arranged along the inner edge of the membrane in two rows, an inner and an outer. The feet of Corti's rods are separated at some distance on the basilar membrane, but the rods are inclined toward each other and are united at the top, leaving between them and the basilar membrane the *tunnel of Corti*. The inner rods are more numerous than the outer, so that the latter are fastened rather between than to the ends of the former. Leaning against the inner or median side of the inner row of rods is a single row of hair cells (Fig. 409), much like those described as seated on the maculæ and cristæ of the labyrinth, to which filaments of the auditory nerve are applied. On the inner face of these hair cells are several rows of columnar epithelial cells supported by a base of nuclei. External to the outer row of rods, and separated from it by a space, are four parallel rows of hair cells known as the *cells of Corti*. The hair cells do not rest upon the basilar membrane, but are upheld by four rows of specialized bodies, the *cells of Deiters*, inserted between and outside them and supported below by the basilar membrane. Outside these structures are several rows of columnar epithelial cells. The rods of Corti are peculiarly shaped at the top, the upper extremity of each being bent at an angle so as to project externally and parallel with the basilar membrane; these projections are the *phalangar processes* of the rods. These processes form the points of attachment, or the beginning, of the *reticulate membrane* (*membrana reticulata*), a peculiar network-like structure formed of cuticular rings and cross bars (not shown in the figure). The reticulate membrane stretches across the outer rows of hair cells, the body of each of which is enclosed and is held at the top within a ring of the network. The inner or median face of each cell of Deiters is modified into a cuticular thread which is fused below to the basilar membrane and above to a ring of the reticulate membrane.

A sheet of radially fibrillated tissue is attached to the vestibular lip of the *limbus*, a promontory composed of connective tissue resting upon and fringing the edge of the *lamina spiralis*. This sheet is known as the *tectorial membrane* (*membrana tectoria*) and reaches out over the organ of Corti as far as the outermost row of hair cells (Fig. 409). It is said, when in place, to lie in actual contact with the rods of Corti and the free ends of the hair cells, and it has been presumed to serve as a damper for the vibrations imparted to the organ of Corti. Howard Ayers* differs, in essential particulars, in his interpretation of some of the structures of the sensory organ of the cochlea from the current views which have been presented above. Thus Ayers asserts "that the so-called membrana tectoria is nothing more than the matted mass of hairs which spring from the tops of the hair cells and form a waving plume on the crest of the ridge of the organ of Corti."

He also holds the *membrana reticulata*, and several other structures described by different authors, to be nothing more than artifacts produced by the methods of preserving and manipulating the specimens.

Turning now to the connection of the sensory organ with the central nervous system, it is found that the cochlear division of the auditory nerve, together with the nutrient blood-vessels, penetrates the modiolus at its base and runs up through the spongy interior of the bony pillar (Fig. 408). As the nerve ascends through the modiolus its fibres are gradually given off to run in a radial direction between the bony plates of the lamina spiralis. A collection of nerve cells forming the *ganglion spirale* is interposed in the course of the auditory fibres at the base of the spiral lamina. The fibrils produced by splitting up of the auditory nerve fibres are generally believed to terminate in clusters about the bodies of the hair cells.

Function of the Sensory Organ of the Cochlea and Its Mode of Action.—There is no doubt that the basilar membrane and the organ of Corti are devoted to translating the vibrations of physical sound into physiological nerve stimuli. More than this, there is little doubt that the cochlear sense organ is an instrument for the analysis of the composite air waves, however complex in their genesis, into the simple pendular vibrations of which they are made up. It is the apparatus through which the period, phase, amplitude, and rate of motion of air particles are translated into auditory impulses which give rise to conceptions of harmony and discord. It is the musical organ of the ear. When we inquire into the way in which the cochlear instrument does its work, we are reduced to the use of hypotheses founded on the action of artificial instruments. The complexity of the organ of Corti in the ear irresistibly demands for it an important function in the acoustic process. But in singing birds, that must be supposed to have an "ear" for music, the organ of Corti is not developed. The radial fibrillation of the basilar membrane early suggested that it represented essentially a series of wires stretched side by side and capable, like those of a piano, of being thrown into sympathetic vibration by impulses reaching them from without. Calculation shows that the fibres are sufficient in number and vary enough in length to more than account for the known powers of the ear in its discrimination of pitch. The fibres of the basilar membrane are cemented laterally by a substance apparently little adapted to transmit vibrations. It may be supposed then, as Helmholtz first pointed out, that composite vibrations traversing the labyrinthine fluids are analyzed by the fibres of the basilar membrane, each fibre responding most powerfully to its own fundamental tone, and that thereby selected groups of the host of nerve fibrils supplying the hair cells are stimulated each with a particular rate and intensity of irritation which, transmitted to the brain, there excites specific sound sensations; the mind again combining these simple sound sensations into complex harmonies having little resemblance to their composing elements.

* Ayers: "The Vertebrate Ear." Journ. of Morphology, May, 1892.

The possibility of giving a satisfactory explanation of the function of the organ of Corti must be abandoned at the outset. The rods of Corti apparently serve as a supporting mechanism for the sensory epithelium. It has been supposed that they serve to pick up and magnify vibrations of the basilar fibres, and, through the medium of the reticulate membrane, transmit such irritations to the hairs of Corti's cells. There is no doubt that the ciliated "cells of Corti" are the special, and probably the only, peripheral sense organs of the auditory nerve. The cilia springing from their free ends are usually regarded as the sensory structures upon which the vibrations immediately act. If Ayers is correct in his opinion that the *membrana tectoria*, instead of being a damper for the vibrations for the organ of Corti, is really a mass of cilia or hairs torn off from the ends of the hair cells, great strength would be given to that view according to which the hairs themselves are the structures set into sympathetic vibration by the waves of the endolymph, not that their stimulation depends upon movements indirectly transmitted from the basilar membrane. In considering this view, it is significant that the scala vestibuli, the vibrations of whose perilymph it would seem should be more powerful than those within the scala tympani, adjoins the canalis cochlearis on the side next the free ends of the hair cells and away from the basilar membrane. Finally, Rutherford* has proposed the theory that the auditory nerve filaments simply transmit to the brain without analysis vibrations applied to them, much as a motor nerve carries to its muscle the impulses generated by induction currents. The basilar membrane, according to this view, vibrates as a whole, and has somewhat the relation to the nerve that a telephone plate has to the conducting wire of the instrument.

Functions of the Vestibular Sacs and of the Semicircular Canals.—Experiments upon the lower animals and the results of aural disease in man have rendered it extremely probable that the semicircular canals are peripheral organs for the complex *sense of equilibrium*, and that they give rise to perception of the movements of the head. There is reason for believing that the sensory cells of the *saccule* and *utricle* also serve as equilibrating organs, giving rise to sensations determined not so much by movements of rotation as by those in a straight line, and to some extent determining the position of the head while at rest. It is thought that the *otoliths* resting upon the hairs of the sensory cells, by their weight and inertia, aid or arouse the excitement of these cells according to the position of the head (see article on *Equilibrium*).

In the ears of fishes the cochlea is wanting, but the vestibular sacs, and especially the masses of otoliths in them, are well developed. But fishes respond to vibrations which may be supposed to arouse auditory sensation just as well when the labyrinth is removed as when it is present, probably through some cutaneous sense.† Such considerations indicate that sounds excite in these creatures other sensations than those of audition as we understand it. It is worth observing that the vestibular branch of the auditory nerve, that supplying the cristæ and maculæ, differs in its characters, in its development, and in its central connections from the cochlear branch of the same nerve. Some have supposed that the sensory cells of the maculæ are excited by the heterogeneous vibrations which we recognize as noises, while musical sounds need the cochlear organ for their interpretation.

Comparison of Visual and Auditory Sensations.—No definite relation can be shown to exist between visual and auditory sensations as such, because they are different in quality. A man born blind may describe the blare of a trumpet as having the color scarlet, but such a statement is evidently only a metaphor expressing the relations of the psychical effect of the trumpet's note and the blind man's inference as to the associations suggested by the color. It is an interesting fact that the language of visual sensation is continually employed in illustrating peculiarities of sound, as in indicating the *quality* as the *color* of the note. In the same way other sensory impressions are used to illustrate visual description, as "warm" and "cold" colors. The intimate association of sound with color in certain persons is an interesting fact of psychology.

Both the auditory and the visual sensory cells are brought into functional activity by physical vibrations, in the one case of ether and in the other of labyrinthine fluid. That continuous sensation shall be aroused these vibrations must be repeated at a definite rate. We have found (p. 612) that the lowest rate which is recognized as sound represents a vibration rate of 16 to 24 per second, while the highest note which is still audible varies in different individuals from 16,000 to 40,000 per second. In musical execution and in the ordinary uses of life the auditory range embraces about seven octaves, though the extreme range of hearing may be eleven octaves. Visual impressions, as those from alternating black and white sections of a rotating disc, fuse together when the different sensations succeed one another at an interval varying from one-tenth to one-fiftieth of a second, the interval being shorter with stronger illumination. But the ear is able to distinguish apart vibrations recurring as "beats" at the rate of 132 per second. The rate of succession of air waves falling upon the ear is marked in consciousness as a particular pitch. When separate luminous impressions, as those of a series of electric sparks, succeed one another with sufficient rapidity, the effect is that of a steady light; there is nothing analogous to musical pitch produced by increasing the rate of stimulation. Ether waves must represent a certain rate of vibration in order to excite visual sensation. The fastest vibration represented in the visible spectrum is less than twice the rate of the slowest; so that the range of vibration in the visual spectrum is included within a single octave. Difference of vibration rate, or of the factor usually considered the *wave length*, in ether, produces that peculiar variety of visual sensation known as color.

The important visual phenomenon of fatigue finds its analogue in auditory sensation. For if a simple musical tone is sounded and immediately thereafter a composite note of which that tone is an upper partial, the note will be found to differ from its normal quality because it falls upon an ear disproportionately fatigued for one of its component tones.

Judgments of Direction and Distance. Ventriloquism.—The direction and distance from which sounds come to the ear are not perceived directly, but our estimate of them is a judgment based on the loudness and quality of the sound sensation, combined with a power of reasoning from past experience. Thus, in seeking to discover the direction whence a sound comes, it is usual for an observer to turn the head to the position in which the sound is heard loudest, and thus to form an opinion as to its source. Errors of judgment as to direction are frequent, owing to the sound reflected from some object appearing louder than that coming in a direct line from its source. It is said that when there is total deafness in one ear, every sound seems to have its origin on the side of the healthy ear.

When the eyes are closed and the head is unmoved, sounds produced anywhere in the median plane of the head are very imperfectly localized. There is a tendency to refer such sounds in a direction above and in front, no doubt because this is the space from which most sounds noticed come to us.

The quality as well as the loudness of a sound varies according to the distance of its source. Thus, the lower tones of a composite note die away earliest as a sound recedes, bringing the overtones into undue prominence. The art of the ventriloquist consists largely in altering the quality of the sounds he produces to imitate the quality they would naturally have if arising under the conditions which he would lead his hearers to believe to be their origin. A comparatively feeble sound near at

* Rutherford, W.: "A New Theory of Hearing." Journ. Anat. and Phys., xxi., 166. (Quoted in Hermann's Jahresbericht d. Physiologie, Bd. xv., S. 108.

† M. Foster: "Text-Book of Physiology," pt. iv., p. 1494, 1900.

hand may have the same quality as a very loud one heard at a distance; thus a frog croaking in an adjoining room was once mistaken by the writer for a large dog barking outside the building.

Acuteness of hearing differs greatly in normal individuals, and tests frequently show disparity in the sensitiveness of the two ears. The hearing ability of children is said to improve up to the age of twelve years. There is no functional relation between keenness of hearing and sensibility to pitch.*

Albino animals and also white cats and dogs with blue eyes are usually deaf. Rawitz † has found the cochlear sense organ degenerated in such cases.

It seems probable that congenital deafness, at least, is inheritable, and that Graham Bell's prediction as to the establishment of a race of deaf mutes from the intermarriage of such unfortunates may be verified.

(In the foregoing pages the author has made some use of his article on Hearing in the "American Text Book of Physiology.") *Henry Sewall.*

AUDITORY CANAL, ANATOMY AND PHYSIOLOGY OF.—The external auditory canal, or meatus auditorius externus, extends from the bottom of the concha to the tympanic membrane, and serves to convey sound vibrations to the middle ear.

It develops in the embryo from the persistent portion of the first outer visceral furrow, making its appearance during the fourth week of fetal development.

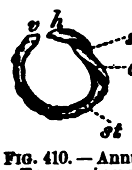


FIG. 410.—Annulus Tympanicus of the Left Side, as Seen from the Inside of the Tympanum. (After Gruber.) *h*, Anterior, *v*, posterior upper end; *sm*, sulcus malleolaris; *ct*, crista tympanica; *st*, sulcus tympanicus.

The centre of ossification shows itself during the third month in the lower wall of the membranous canal.

At birth this bone development has assumed the shape of an incomplete ring, *the annulus tympanicus.* This ring presents a slight groove along its concave border for the attachment of the tympanic membrane, the deficiency upward and backward forming the so-called Rivinian fissure or notch.

At birth the auditory canal is a partially collapsed tube, the roof and floor being in contact throughout a considerable portion of its extent and containing small masses of broken-down epithelial scales and vernix caseosa.

During the first few years of life we find proportionately little difference in the length of the canal when compared with that of the adult, 20 mm. being about the average length at birth. The calibre of the canal is smaller and more oval in shape. The general direction is straighter, passing inward with a decided downward inclination, so that when examining the membrana tympani in the child the speculum can be used to more advantage if the external ear be pulled downward and outward.

The fully developed adult canal is made up of an inner bony portion and an outer cartilaginous and membranous portion. The bone formation extends from the annulus tympanicus outward in the membranous canal, forming the anterior, inferior, and a portion of the posterior bony wall of the perfected canal. The roof is formed by the horizontal plate of the squama and the root of the zygoma; the posterior wall by the annulus, squama, and mastoid prominence.

The outer portion of the canal is a continuation inward of the cartilage of the auricle, the cartilaginous elements being absent in the upper and posterior portion, this gap being filled in by fibrous membrane. The amount of cartilage making up the canal is found to lessen as it extends inward; at its commencement two-thirds of the circumference is composed of cartilage, at its attachment to the bony canal it represents less than one-third of the lower front wall. The cartilaginous portion is attached to the roughened edge of the tympanic ring—now developed into the bony external auditory canal—by fibrous tissue. The fibrous portions of the upper and back wall become merged into the periosteum of the mastoid and squamous portions of the bony canal.

The length, size, and shape of the canal varies according to age, race, and the form of cranial development.

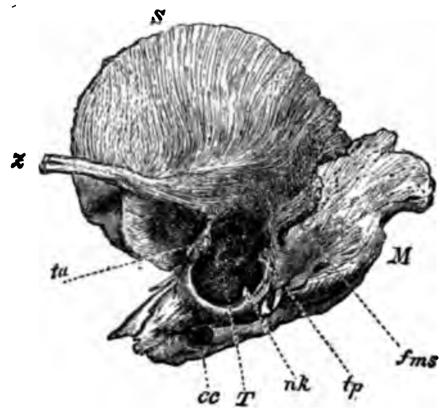


FIG. 411.—Temporal Bone of New-Born Infant. (After Gruber.) *S*, Upper part of squamous portion; *M*, mastoid portion; *Z*, zygomatic process; *T*, tympanic cavity; *fms*, fissura mastoides squamosa; *cc*, foramen caroticum; *ta*, *nk*, *tp*, bony processes representing the beginnings of growth outward on the part of the annulus tympanicus.

The length of the canal is stated variously by different authors, depending on the points from which the measurements are taken; the average length from the bottom of the concha being about 24 mm., of which 16 mm. are found to be bone and 8 mm. cartilage.

Von Troeltsch has given the most complete measurements of the different walls. Starting from a plane drawn from the posterior wall at right angles to the axis of the canal, he found the following measurements: Anterior wall, 27 mm.—9 mm. cartilage, 18 mm. bone; inferior wall, 26 mm.—10 mm. cartilage and 16 mm. bone; posterior wall, 22 mm.—7 mm. cartilage, 15 mm. bone; superior wall, 21 mm.—7 mm. cartilage, 14 mm. bone; the variations in the length of the different walls being due to the oblique position of the tympanic membrane at the inner end of the canal. The shape of the canal at the external orifice is somewhat oval, the long axis inclining slightly backward from the vertical.

Ostman, from a study of 2,302 skulls, found that with the dolichocephalic skull the canal was shorter and more circular, while in the brachycephalic skull the canal was longer and more oval. It is a clinical fact that in the negro race the canal is more circular and straighter, making it often unnecessary to resort to the speculum in order to view the tympanic membrane.

FIG. 412.—*m*, Cartilaginous meatus; *c*, inner extremity of the cartilaginous meatus; *ii*, fissuræ Santorini.

The smallest diameters of the canal are near the end of the cartilaginous portion, and in the bony canal close to the inner third. The following diagrams show the shape and size of the canal at different parts of its course, as found by Bezold from a study of casts of the cavity.

The direction of the canal is sigmoid. In its outer third it is inclined somewhat forward and ascends very

* Seashore: Studies in "Psychology," Bull. Univ., Iowa, vol. ii., 1899.

† Rawitz: Zoölogischer Jahresbericht, 1896, Arch. f. Anat. u. Physiol., 1897.

slightly. It then turns sharply backward and is horizontal near the middle third, where it again changes its course, the inner portion curving forward and decidedly downward.

In the cartilaginous floor of the canal are found one small and two large fissures running in a circular manner, called the fissures of Santorini. These spaces are filled

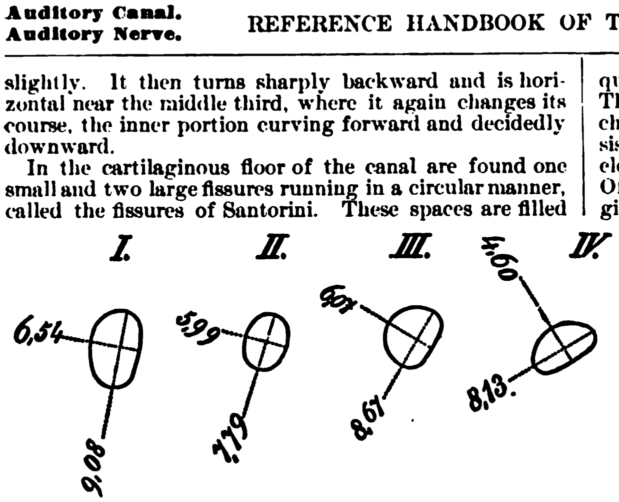


FIG. 413.—Diagram Showing the Form and Measurements of Sections Across the External Auditory Meatus. (From Schaefer, after Bezold.) *I.*, At commencement of cartilaginous portion; *II.*, near end of cartilaginous portion; *III.*, near beginning of osseous portion; *IV.*, near end of osseous portion. (The measurements are in millimetres.)

in with fibrous tissue and allow the passage of blood-vessels; at the same time they permit free motion of the canal, thus favoring the straightening of the meatus during examinations with the speculum. These fissures are sometimes the channel through which an abscess in the parotid gland may find its exit.

The canal is lined by a continuation of the cutaneous covering of the auricle. In the cartilaginous portion the skin is 1 to 2 mm. in thickness and loosely attached to the perichondrium. In the bony canal it is thinner and firmly united to the periosteum.

Kaufman describes a number of ridges or vascular

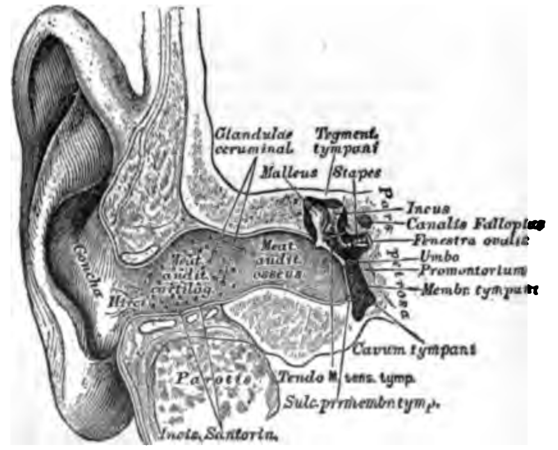


FIG. 414.—Vertical Section of the External Auditory Canal and Tympanic Cavity. (After Heitzmann.)

papillæ which occupy a circular position in the skin of the osseous portion of the canal, close to the membrana tympani, and which, in inflammatory conditions of the canal, may become quite large. Politzer states that these papillæ are often the starting point for polypi. At the inner end the skin continues over the membrana tympani and forms its outer layer.

Throughout the cartilaginous part, and extending in a triangular manner into the upper and back wall of the osseous canal, are found numerous hairs and sebaceous glands, and in addition, large oval, convoluted tubular glands resembling in form and structure the sweat gland—the *Glandulæ Ceruminosæ*. These glands secrete the cerumen or ear wax, and are found opening into and around the hair follicles. The hair development is sometimes abundant. The sebaceous glands secrete a small quantity of oily material for lubrication of the skin. The secretion from the ceruminous glands when first discharged is of a yellowish brown color and soft in consistency, but in a short time evaporation of the watery elements causes the mass to thicken and it becomes darker. Often it becomes inspissated, and by blocking the canal gives rise to much temporary discomfort. The function of the cerumen is probably to protect the ear from the entrance of insects and foreign particles that may get into the canal.

Röhrer found a number of organisms to exist in plugs of ear wax. It is of a pungent, bitter taste, and chemically, in addition to oil from the sebaceous glands, is made up of a dry material not soluble in water, alcohol, or ether, and of potash, stearin, a trace of soda and lime, and 0.1 per cent. water, mixed with numbers of broken-down epidermic exfoliations and loose hairs.

Of the very greatest importance to the aural surgeon is the surgical anatomy and relationship of the canal. These differ somewhat in the ear at birth and in the adult. At birth the only portion of the canal found to be bony is the *annulus tympanicus*. This is attached to the squama in front, below and behind to the petro-mastoid portion. Along the external margin of this ring are seen two small tubercles that are the starting points for the future bone development forming the anterior and lower wall of the canal. They do not immediately unite as one process, often leaving a gap until after the fifth or sixth year.

The roof of the canal is formed from the squama. As development takes place the portion below the temporal line assumes a horizontal position and presents two plates of bone containing between them honeycombed spaces. The superior plate forms a part of the floor of the middle cranial fossa and has resting upon it the dura mater. The lower plate, near its inner extremity, suddenly drops down in such a manner as to become wedge-shaped; it forms the outer wall of the attic of the tympanum, called the scutum, and gives attachment to the upper margin of the drum head. The cell spaces contained between the plates of the roof of the canal frequently communicate with the antrum and with the pneumatic spaces found as far forward as the root of the zygomatic process. Clinically these spaces are of importance since they may be the seat of suppuration in conjunction with mastoid diseases, and must not be overlooked in operations in which all the cellular spaces are suspected of containing pus.

The anterior bony wall of the meatus is the thinnest of the canal. It is slightly convex on the meatal face. Its front surface assists in the formation of the glenoid cavity in which rest the condyle of the lower jaw and part of the parotid gland. Blows on the lower jaw are therefore likely to fracture the wall of the canal. The floor is formed by the bony growth of the tympanic ring. It is thick and compact; toward the meatus the surface is convex except close to the membrana tympani, where a small concavity is found—"the Sinus of Meyer"—in which foreign bodies may lodge. The position of this concavity is such that it is often difficult to detect the presence of these foreign bodies and to remove them.

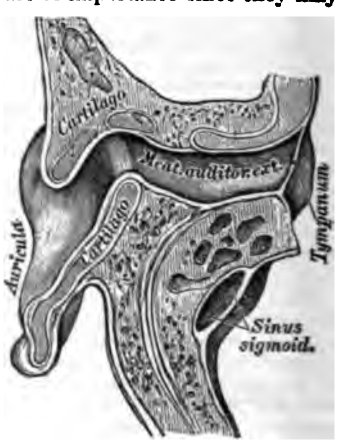


FIG. 415.—Horizontal Section of the Left External Auditory Canal. (After Heitzmann.)

The posterior wall of the osseous meatus is of much

surgical importance. It is formed by the union of the tympanic ring with the squama, and later with the anterior plate of the developed mastoid, this plate being quite thin and separating the canal from the cell spaces contained in the mastoid. Often the groove for the lateral sinus is in close proximity to this wall.

At the juncture of the upper and the posterior wall the scutum forms a portion of the outer wall of the mastoid antrum. In suppurative diseases of the tympanic cavity often carious tracts (fistulæ) are found in this region; they lead into either the tympanic attic or the antrum of the mastoid, and call for surgical interference. Just external to the upper posterior margin is often found a small bony spine—the supra-meatal spine—which is of value as a surgical landmark in the operation for opening the mastoid antrum.

In the fully developed ear the drum head is placed in an oblique position, the upper and back part forming an obtuse angle of about 135°, while the lower and anterior portion forms an acute angle of about 40°, with the canal wall.

The arterial supply to the auditory canal is quite abundant. The posterior auricular, a branch of the external carotid, sends a branch called the auricular. It passes in at the junction of the cartilaginous with the bony canal, and supplies the back wall of the canal, anastomosing with the anterior auricular, a branch of the temporal, which enters the anterior wall of the canal behind the condyle of the lower jaw. The tympanic branch of the internal maxillary enters the tympanic cavity through the Glaserian fissure, and sends a branch that supplies the skin of the canal adjacent to the membrana tympani. The veins take an irregular course. They empty their blood either directly (and this is the rule) into the external jugular or indirectly by way of the temporal or the internal maxillary vein.

The nerve supply is, first, from the auriculo-temporal branch of the inferior maxillary division of the fifth nerve. Three small branches of this nerve supply the skin on the anterior wall and in the cartilaginous portion. Second, the auricular branch of the pneumogastric—"Arnold's nerve"—enters the back wall of the canal at its junction with the mastoid, and supplies the larger portion of the bony canal and a part of the back wall of the cartilaginous section. Irritation of this nerve by the accumulations of wax, by foreign bodies, or by the speculum when the ear is being examined or cleansed, produces the familiar reflex ear cough.

But little seems to be known regarding the lymphatic vessels contained in the walls of the external canal. Politzer states that they are probably connected with the lymphatic glands overlying the parotid, by way of the fissures of Santorini, since it is a matter of clinical observation that swelling of the lateral cervical glands often occurs in inflammatory conditions affecting the meatus.

The skin lining the auditory canal maintains all the histological characteristics of the skin in other parts of the body, although that part which lines the bony canal becomes very firmly united to the periosteum and altered in color. In its development there is a gradual growth outward of the skin, thus producing a constant tendency for the ear wax to move outward, this being further facilitated by the pressure of the condyle of the jaw, which in mastication constantly pushes the parotid gland against the anterior wall of the canal and somewhat influences its lumen.

The sinuous course of the canal is such that sound waves do not strike the membrana tympani directly, but are reflected from the walls of the canal and are thus modified in their intensity. Politzer states that the two most important points where this reflection takes place are on the back wall of the cartilaginous canal and on the anterior inferior portion of the bony canal.

The size of the canal plays no influence in the acuteness of hearing, although Burnett observes that large straight canals are more likely to be found in those possessing a so-called ear for music. *J. Morrison Ray.*

AUDITORY NERVE AND ITS END ORGANS.—COMPARATIVE ANATOMY AND PHYLOGENY.—The functions of audition and equilibration seem to be closely associated throughout the animal kingdom. The so-called auditory organs, or otocysts, of the invertebrates, if we may trust the results of most recent experimental studies, are in the majority of cases concerned largely, if not wholly, with equilibrium, though in some cases (notably among insects) true auditory organs undoubtedly exist. The structure of these organs is usually similar to that of the organs in the labyrinth of vertebrates.

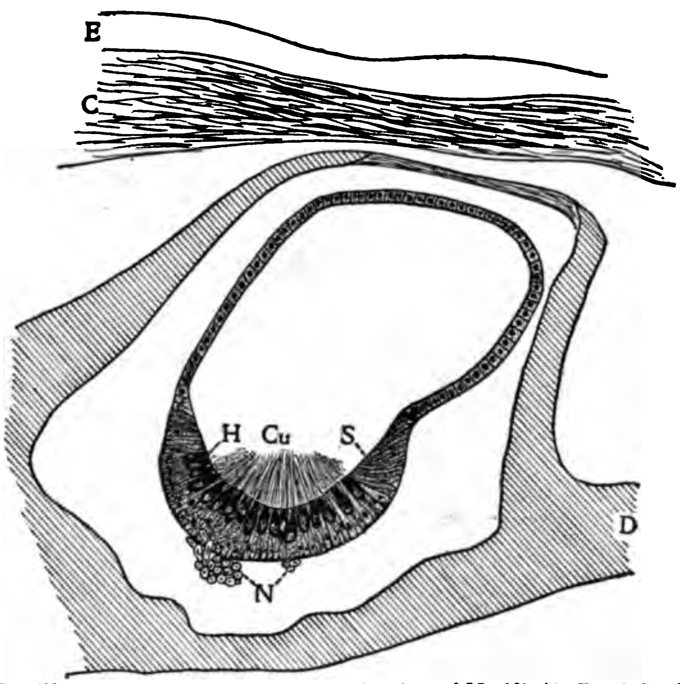


FIG. 416.—Section through a Typical Lateral-Line Organ of *Menidia* (the Fourth Canal Organ of the Mandibular Line of Fig. 417). *C*, Corium; *Cu*, cupula, composed of hairs from the hair cells matted together and more or less gelatinized; *D*, dentary bone; *E*, epidermis; *H*, hair cells, or specific sensory cells; *N*, nerve fibres supplying the latter; *S*, supporting cells.

For the proper morphological comprehension of the eighth nerve and its terminal organs we must look far back to the early phylogenetic stages of its development in the vertebrates. The fishes possess a system of cutaneous and subcutaneous sense organs, the so-called lateral-line organs (Fig. 416), widely distributed over the head and trunk. Part of these are in canals (the lateral-line or "mucous" canals), and part are variously distributed over the skin, either naked or sunken in separate pits (the pit organs of ganoids and ampullæ of elasmobranchs); but all closely resemble structurally the maculæ and cristæ of the internal ear, and all are innervated by nerves which arise with the auditory nerve from the tuberculum acusticum. These lateral-line nerves go out with the vagus and facial roots and are conventionally associated with these nerves. They have, however, really nothing to do with them, but are more logically associated with the auditory nerve to comprise the "acustico-lateralis" system of nerves (*cf. Cranial Nerves*). The peripheral distribution of this component in a typical fish is expressed in the accompanying diagram (Fig. 417).

The chief function of the acustico-lateral system of nerves in the fishes is undoubtedly equilibration. This has been demonstrated not only for the nerves of the lat-

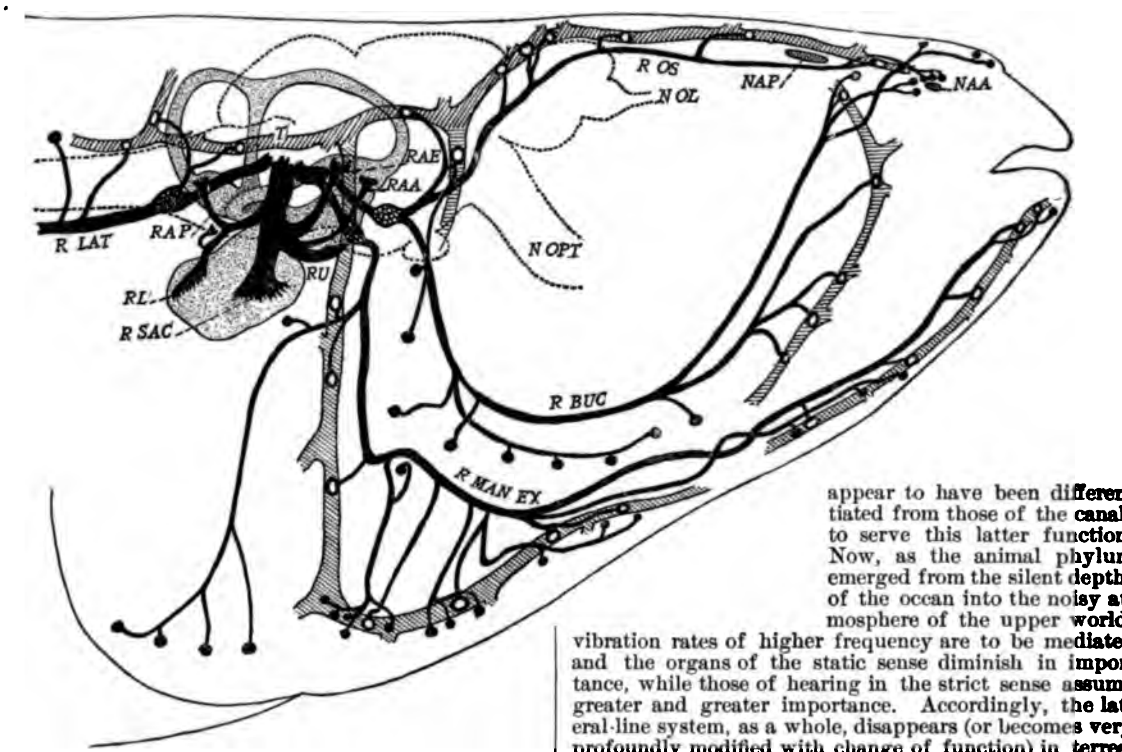


FIG. 417.—The Acustico-Lateral System of Nerves with Their Peripheral End Organs, as Seen from the Right Side, in the Silver Side, *Menidia*. Reconstructed from serial sections by projection upon the sagittal plane. × 12. The dotted outline represents the position of the brain, the lateral-line canals are shaded with cross-hatching, the auditory labyrinth is stippled, and the nerves are drawn in black. The organs of the lateral-line system are drawn as black discs when naked on the surface of the skin, and as black circles when lying in the canals. For the relation between the acustico-lateral nerves and the other systems of nerves in this fish, see the more detailed plot from which this was drawn off, in the *Journal of Comparative Neurology*, vol. ix., plate xv., or the *Archives of Neurology and Psychopath.*, vol. ii., plate ii. *NAA*, anterior nasal aperture; *NAP*, posterior nasal aperture; *N OL*, olfactory nerve; *N OPT*, optic nerve; *RAA*, ramulus acusticus ampullæ anterioris; *RAE*, ramulus acusticus ampullæ externæ; *RAP*, ramulus acusticus posterioris; *R BUC*, ramus buccalis facialis; *RL*, ramulus acusticus lagenæ; *R LAT*, ramus lateralis vagi; *R OS*, ramus ophthalmicus superficialis facialis; *R MAN EX*, ramus mandibularis externus facialis; *R SAC*, ramulus acusticus sacculi; *RU*, ramulus acusticus recessus utriculi; *T*, tuberculum acusticum.

eral lines, but for the eighth nerve as well. Compare especially the experimental work of Lee. This author goes so far as to deny the sense of hearing to the fishes altogether, a position which is doubtless too extreme; yet it is clear that hearing, as we understand the term, plays a very subordinate rôle with these animals.

Fishes, which have to maintain their equilibrium in a fluid medium, require a much more elaborate mechanism for the control of the spatial relations of the body than do the terrestrial animals. But the same organs which are adapted to receive stimuli from the pulsations of the fluid within the semicircular and lateral-line canals, due to changes in the position of the body, may also serve to register vibrations of low frequency arising outside of the body, such as the beating of the surf or the movements of the fins of an approaching enemy. The sensory spots of the utriculus, sacculus, and lagena would appear to have been differentiated from those of the canals to serve this latter function. Now, as the animal phylum emerged from the silent depths of the ocean into the noisy atmosphere of the upper world, vibration rates of higher frequency are to be mediated and the organs of the static sense diminish in importance, while those of hearing in the strict sense assume greater and greater importance. Accordingly, the lateral-line system, as a whole, disappears (or becomes very profoundly modified with change of function) in terrestrial animals, since the semicircular canals are here able to perform its functions, while the papilla lagenæ of the

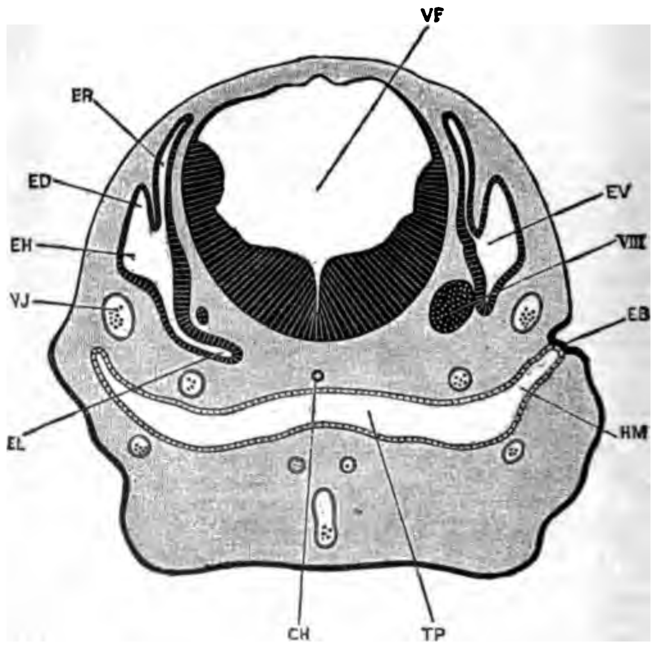


FIG. 418.—A Transverse Section Across the Head of a Rabbit Embryo at the End of the Eleventh Day. The plane of the right half of the figure is slightly anterior to that of the left half. × 30. From Marshall's "Embryology." *CH*, notochord; *EB*, membrane closing the hyomandibular cleft; *ED*, common stem of the two vertical semicircular canals; *EH*, rudiment of the external semicircular canal; *EL*, cochlear canal; *ER*, recessus vestibuli; *EV*, auditory vesicle; *HM*, hyomandibular pouch; *TP*, pharynx; *VF*, fourth ventricle; *VJ*, jugular vein; *VIII*, auditory nerve.

fishes undergoes a succession of metamorphoses until it appears as the cochlea of the mammals.

These alterations in the relative importance of the different members of the acustico-lateral complex are naturally reflected in the central nervous system. We therefore find that the size of the acustico-lateral centres (tuberculum acusticum and cerebellum) in the fishes is directly proportional to that of the peripheral organs of this system. With the development of a cochlea in the mammals, an entirely new set of connections is effected in the oblongata, which are by no means so closely related to the cerebellum as are the end stations of the vestibular root. These are the ventral and dorsal cochlear nuclei, the latter of which projects into the floor of the fourth ventricle, forming the "tuberculum acusticum" of human anatomy. It will be seen, therefore, that this structure is not homologous with the protuberance of the oblongata so named in the fishes, as the latter is the terminal nucleus of the vestibular and lateral-line roots. In connection with the fact that the secondary fibres connected with the cochlear root terminate very largely in the inferior member of the corpora quadrigemina (see below), it is interesting to note that this body appears upon the surface of the brain in the phylogeny contemporane-

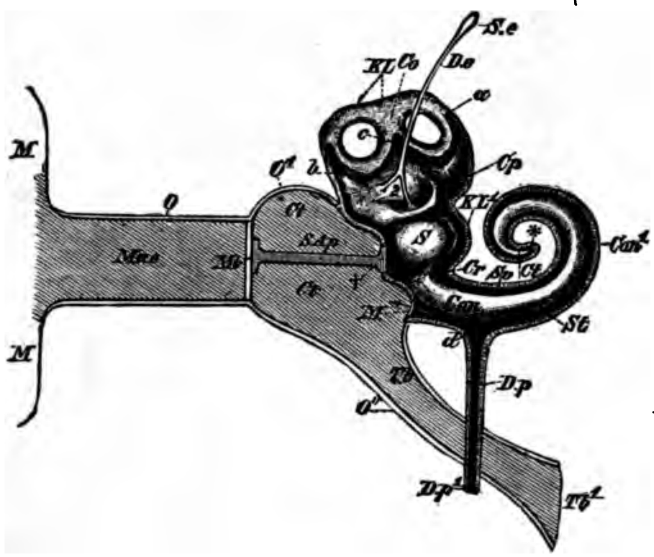


FIG. 419.—Diagrammatic Representation of the Organ of Hearing of Man. (After Wiedersheim.) *Outer ear*—*M*, *M*, auricle; *Mae*, meatus auditorius externus; *O*, its wall; *Mt*, membrana tympani. *Middle ear*—*Ct*, *Ct*, cavum tympani; O^1, its wall; *SAp*, sound-conducting apparatus, which is drawn as a simple rod-like body instead of the auditory ossicles; the place + corresponds to the stapedial plate, which closes the fenestra ovalis; *Tb*, Eustachian tube; Tb^1, its opening into the pharynx; *O'*, its wall. *Inner ear*—The bony labyrinth, *KL*, KL^1, for the most part cut away; *S*, sacculus; *a*, *b*, the two vertical semicircular canals, of which one (*b*) is cut through; *S.e*, *D.e*, saccus and ductus endolymphaticus, of which the latter is divided at 2 into two arms; *Cp*, cavum perilymphaticum; *Cr*, canalis reuniens; *Con*, membranous cochlea, which produces at * the vestibular cæcum; Con^1, bony cochlea; *Sv* and *St*, scala vestibuli and scala tympani, which at * communicate with each other at the cupula terminalis (*Ct*); *D.p*, ductus perilymphaticus, which arises from the scala tympani at *d* and opens out at $D.p^1$. The horizontal semicircular canal is not especially designated.

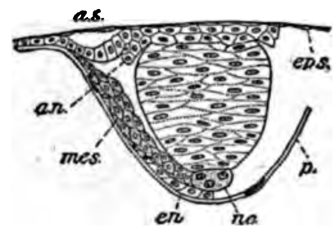


FIG. 423.—Transverse Section through the Head of an Embryo of the Sea Bass of Thirty-five Hours. (After H. V. Wilson.) *a.n.*, Auditory nerve; *a.s.*, auditory saucer; *en*, entoderm; *ep.s.*, epidermic stratum of ectoderm; *mes.*, mesoderm; *nc.*, notochord; *p.*, periblast. The large oval mass of cells in the centre of the figure is the medulla oblongata.

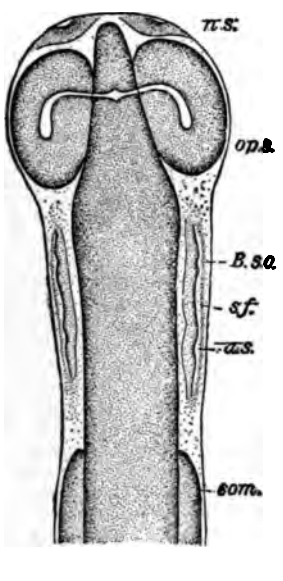


FIG. 420.

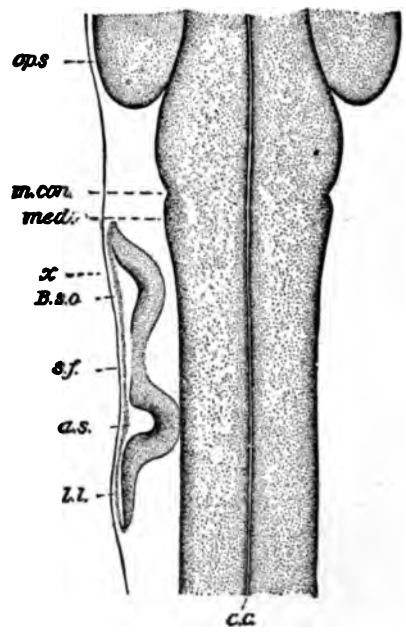


FIG. 421.

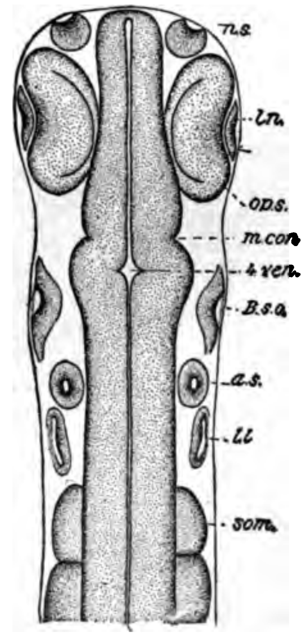


FIG. 422.

FIGS. 420-422.—Surface Views of Embryos of the Sea Bass of Thirty-three, Thirty-seven, and Forty-five Hours. (After H. V. Wilson.) *a.s.*, Auditory sac; *B.s.o.*, pre-auditory lateral-line rudiment; *c.c.*, canalis spinalis; *l.l.*, post-auditory lateral-line rudiment; *ln.*, lense; *m. con.*, constriction separating medulla from mid-brain; *med.*, medulla oblongata; *n.s.*, nasal sac; *op.s.*, optic sac; *s.f.*, sensory furrow, common acustico-lateral rudiment; *som.*, somites; *4 ven.*, fourth ventricle.

ously with the cochlea. The cerebellum has been mentioned as a secondary end station for the acustico-lateral system of nerves. As the organ of equilibration (and of the static senses in general) for the body, this was

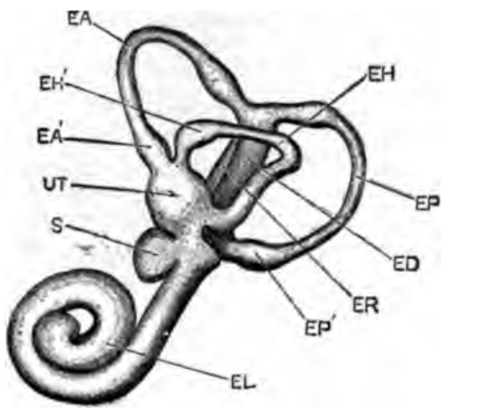


FIG. 424.—The Left Auditory Vesicle of a Human Embryo of the Eighth Week, Seen from the Left Side. (After W. His, Jr., from Marshall's "Embryology." × 17. *EA*, Anterior vertical semicircular canal; *EA'*, ampulla of anterior vertical semicircular canal; *ED*, common stem of the two vertical semicircular canals; *EH*, horizontal semicircular canal; *EH'*, ampulla of horizontal semicircular canal; *EL*, cochlea; *EP*, posterior vertical semicircular canal; *EP'*, ampulla of posterior vertical semicircular canal; *ER*, recessus labyrinthi; *S*, sacculus; *UT*, utriculus.

probably its primary connection. But these static functions are served by all of the other senses as well (except, perhaps, the olfactory), so that the terminal nuclei of the other sensory nerves have also effected secondary connections with the cerebellum.

The middle and external ear do not appear in the fishes, the vibrations of the surrounding medium being transferred to the labyrinth through the tissues of the head. But air-breathing vertebrates require some intermediary mechanism to intensify the more feeble aërial vibrations. Accordingly, the middle ear, with its contained auditory ossicles, is seen for the first time in the Amphibia. The phylogeny of the auditory ossicles has been the subject of endless investigation, and there is still no agreement upon the details of this history. The internal ear in the lower fishes clearly lies in the hyoid segment of the head. With the gradual enlargement of the brain case in the higher animals, the greater portion of the facial skeleton of the fishes is absorbed into the cranium. According to the most recently published research (Kingsley, 1900), the derivation of the auditory ossicles is as follows: The malleus from the articulare (in part), the incus from the quadrate, and the stapes from the hyomandibulare, the first two being derived from the mandibular arch, the last from the hyoidean.

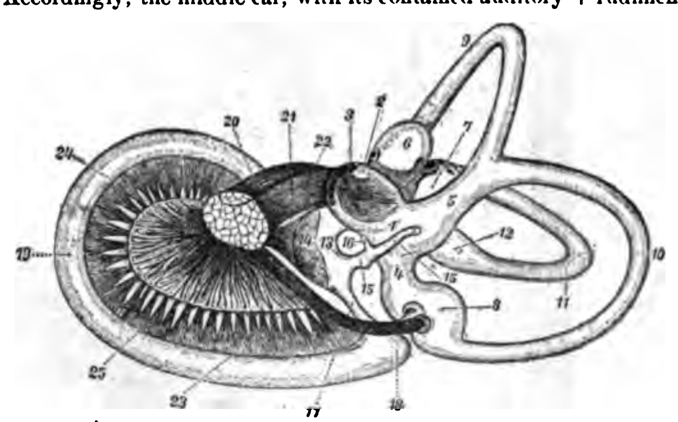


FIG. 425.—The Membranous Labyrinth of the Right Internal Ear of a Human Embryo at the Fifth Month, Seen from the Medial Side. (After Retzius, from Barker's text-book.) 1–5, Utriculus; 2, recessus utriculi; 3, macula acustica utriculi; 4, sinus posterior; 5, sinus superior; 6, ampulla membranacea superior; 7, ampulla membranacea lateralis; 8, ampulla membranacea posterior; 9, ductus semicircularis superior; 10, ductus semicircularis posterior; 11, ductus semicircularis lateralis; 12, widened mouth of crus simplex of the lateral semicircular canal opening into the utriculus; 13, sacculus; 14, macula acustica sacculi; 15, ductus endolymphaticus; 16, ductus utriculo-saccularis; 17, ductus reuniens; 18, cæcum vestibulare of ductus cochlearis; 19, ductus cochlearis; 20, nervus facialis; 21–24, N. acusticus; 21, N. vestibuli; 22, N. saccularis; 23, N. ampullaris inferior; 24, N. cochleæ; 25, distribution of N. cochleæ within the lamina spiralis ossea.

The Eustachian tube is now quite generally regarded as the derivative of the spiracular canal, a rudimentary gill cleft present in some of the lower fishes between the hyoid and mandibular arches. In the mammals this tube never quite reaches the surface of the head, but is cut off by an epithelial membrane composed merely of a layer of ectoderm and a layer of entoderm without any intervening mesoderm (*EB*, Fig. 418). This membrane becomes the tympanic membrane, the portion of the tube within it the Eustachian tube, and the pit leading from it to the surface the external auditory meatus (Fig. 419).

FIG. 426.—Scheme of the Peripheral Termination of the Nervus Vestibuli. (After Retzius, from Barker's text-book.) *co*, Central nervous system; *fz*, supporting cell; *hz*, hair cells; *sn*, neurite of N. vestibuli; *sz*, cell body of vestibular neurone.

EMBRYOLOGY. — That the ear is related to the lateral-line organs of the fishes is shown by its embryology, as well as by comparative anatomy. In all fishes there appears behind the eyes a thickened patch of ectoderm from which both the ear and the lateral-line canals of the head and trunk arise. The rudiment of the ear appears first, and then the two lateral-line rudiments on either side of it. In cases in which the ectodermal epithelium at this stage is simple, the whole epithelium in the auditory portion of this patch invaginates to form the "auditory saucer," and later a vesicular sac which sinks down below the surface. But in other cases, in which the ectoderm becomes earlier two-layered, it is only the inner, or nervous layer, which participates in this invagination, and the auditory vesicle never communicates with the surface of the body. Three successive stages in the differentiation of the auditory sac and lateral-line rudiments of the sea bass are shown in the accompanying figures (Figs. 420–422). A section through the auditory sac at about this period (Fig. 423) shows the auditory saucer in process of formation from the nervous layer of the ectoderm, the outer layer not participating. Sections taken cephalad and caudad of this point show that the lateral-line rudiments of the sea bass resemble this very closely. Though there is considerable variation in the mode of origin of the lateral lines in different fishes, they all have this in common: that they arise from the same ectodermal thickening as the ear. In the figure last cited it will be noticed that the invaginating ecto-

derm is directly continuous dorsally with that of the central nervous system, and that the auditory nerve is growing out from the same region, viz., the neural crest (*cf. Cranial Nerves*).

The auditory saucer, whether formed from the whole of the ectoderm or only from its inner layer, soon closes up and withdraws from the skin to form a vesicular sac, the auditory vesicle. In the elasmobranchs the vesicle retains its connection with the outer surface to adult life by means of a slender tube, the ductus endolymphaticus, in this point resembling the lateral-line canals, which open freely to the surface by means of a series of pores. But in all of the higher animals this connection is lost, though the tube persists as a blind pouch, the recessus vestibuli (*ER*, of Fig. 418), which later in man becomes the path of communication between the sacculus and the utriculus. These latter chambers are formed by the folding of the walls of the vesicle, and contemporaneously with this process the semicircular canals are pinched off from the dorsal or utricular portion, while the cochlea grows down from the saccular portion. The form of the membranous labyrinth of the human embryo of the eighth week is shown by the accompanying figure (Fig. 424).

While the auditory vesicle is still in a quite undifferentiated condition, its lining epithelium develops a patch of sensory cells which enlarges very irregularly in such a way that during the subsequent plications of the walls of the vesicle each of the chambers thus evaginated (except the recessus vestibuli) receives a portion of this modified epithelium. These patches now become separated by non-sensory pavement epithelium and constitute the three cristæ in the ampullæ of the semicircular canals, the maculæ of the utriculus and sacculus and the organ of Corti of the cochlea.

The auditory vesicle, which is primarily ectodermal, at first lies simply embedded in the surrounding mesoderm (Fig. 418). A portion of this mesoderm is added to the vesicle, and thus the definitive membranous labyrinth is formed from both of these germ layers. The enveloping cartilages—which become, when ossified, the bony labyrinth—develop a short distance removed from the membranous labyrinth, and the intervening mesoderm is dissolved, leaving the perilymphatic spaces between the membranous and the bony labyrinth. The scala tympani and the scala vestibuli are the continuations of these spaces into the cochlea, while the scala media is the only part of the cochlea which is lined by a derivative from the original ectodermal auditory vesicle. Accordingly, the organ of Corti is developed in the floor (membrana basilaris) of the scala media.

THE AUDITORY NERVE OF MAN.—The accompanying figure from Retzius (Fig. 425), together with Fig. 419, above, and the preceding accounts of development, will render a detailed description of the accessory auditory apparatus unnecessary. It must be remembered that there are two distinct sensory mechanisms in the eighth nerve and internal ear, mechanisms which have had a common origin and which possibly even in man are only incompletely differentiated from each other. These are the labyrinth, serving the static sense, and the cochlea, the organ of hearing. The maculæ and cristæ of the membranous labyrinth are very simple sensory epithelia, in structure almost identical with the organs of the lateral line figured above. The supporting cells constitute a simple columnar epithelium. Among these cells are the shorter hair cells, or specific sensory cells, extending only about half-way through the thickness of the epithelium. Their relations to the termini of the nerve are shown in the accompanying diagram (Fig. 426).

The organ of Corti of the cochlea, on the other hand, is so complicated that the details of its minute structure are still in large measure obscure. The general relations of the parts of the organ of Corti are expressed by the accompanying diagram (Fig. 427). Neglecting the accessory structures in the organ of Corti, concerning whose structure and functions there is considerable difference of opinion, the sensory epithelium here, as in the organs of the vestibule, consists essentially of a simple columnar non-sensory epithelium (curiously modified), and among its cells shorter specific sensory cells, the hair cells. The latter are related to the terminal ramifications of the nerve very much as are the hair cells of the vestibular organs. That is, according to the majority of authorities, the cochlear nerve ends free among the hair cells, without effecting protoplasmic continuity with their substance.

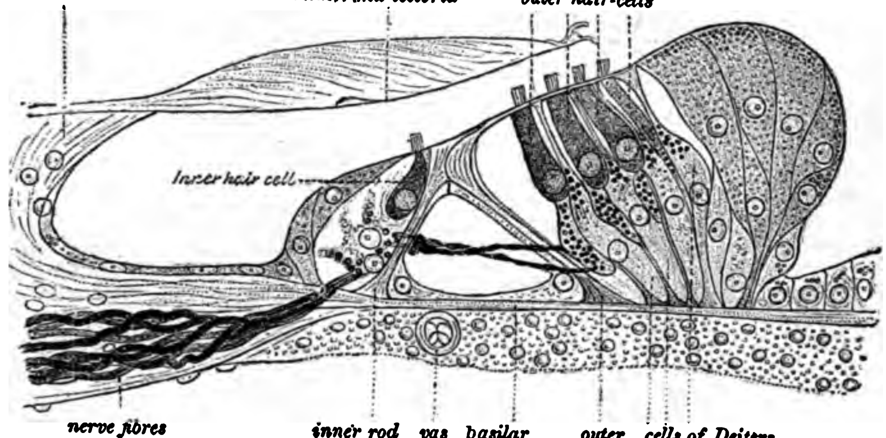


FIG. 427.—Section through the Organ of Corti of the Middle Turn of the Human Cochlea. (After Retzius, from Quain's "Anatomy.")

The division of the auditory nerve into vestibular and cochlear rami, while convenient descriptively, is not of special morphological significance, for, while the vestibular ramus is distributed wholly to sensory organs of the labyrinth proper (superior and external ampullæ and macula utriculi), the so-called cochlear ramus supplies, in addition to the cochlea, the posterior ampulla and the macula sacculi. The two branches of the cochlear ramus last named are termed by Schwalbe the ramus medius, a natural division, as they belong more properly with the vestibular ramus than with the cochlear. The vestibular and cochlear divisions can best be described separately.

Vestibular Ramus—The fibres of this nerve arise from ganglion cells lying in the internal auditory meatus, the vestibular ganglion, or ganglion of Scarpa. These cells, like all of the others connected with the nerves of the internal ear (and the lateral-line nerves of fishes as well), remain bipolar throughout life in all animals. The method of the termination of the peripheral processes about the specific cells of the sensory spots has already been illustrated. The central processes form the vestibular (mesial or anterior) root of the eighth nerve. It enters the brain ventrally and cephalad of the cochlear root, and passes dorsad between the fibres of the restiform body

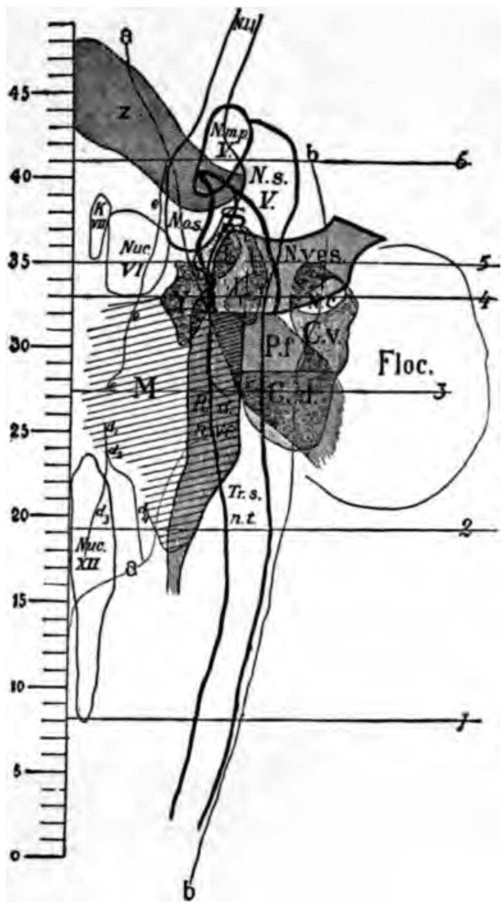


FIG. 428.—Diagram Representing Flat Reconstruction of the Nuclei of Termination of the Cochlear and Vestibular Nerves. (After Florence R. Sabin.) The scale at the left is in the median line; the line *a, a* represents the lateral wall of the ventricle; the line *b, b* corresponds to the lateral outline of the corpus restiforme; the lines d_1 to d_4 and the line *e, e, c* correspond to the sulci in the floor of the fourth ventricle; *C.d.*, nucleus nervi cochleæ dorsalis; *C.v.*, nucleus nervi cochleæ ventralis; *Floc.*, flocculus; *K VII*, knee of the nervus facialis; *L.*, medial portion of nucleus nervi vestibuli lateralis (Deiters); *L*, lateral portion of nucleus nervi vestibuli lateralis (Deiters); *M*, together with *Y*, nucleus nervi vestibuli medialis (Schwalbe); *Nuc. XII*, nucleus nervi hypoglossi; *Nuc. VI*, nucleus nervi abducentis; *P.f.*, pedunculus flocculi; *N. m.p. V.*, nucleus motorius princeps nervi trigemini; *N.o.s.*, nucleus olivaris superior; *N.s. V.*, nucleus nervi trigemini (sensory); *N.c.*, root bundle of nervus cochleæ; *N. vest.*, root bundle of nervus vestibuli; *R.d.n.ve.*, radix descendens nervi vestibuli; *S.*, nucleus nervi vestibuli superior (Bechterew) (area enclosed in the broad black line); *Tr.s.n.t.*, tractus spinalis nervi trigemini; *Y*, nucleus; *y* = antero-lateral portion of nucleus nervi vestibuli medialis: *z*, decussatio nervi trigemini.

and those of the spinal root of the fifth nerve. Mesially of the restiform body the fibres bifurcate, one limb of each fibre turning caudad to form the descending or spinal root of the vestibular nerve, finally to arborize about the cells of the spinal nucleus associated with this tract. The other limbs of these fibres effect various connections in the region dorsally and cephalad of this point. The primary connections of the vestibular root have been thus summarized by Dr. Lewellys F. Barker:

There are at least four well-defined primary nuclei of termination in connection with the vestibular nerve: (1) The nucleus medialis (Schwalbe); (2) the nucleus spinalis (radix descendens); (3) the nucleus lateralis (Deiters); and (4) the nucleus superior (Flechsig, von Bechterew). In addition, the nervus vestibuli comes into direct conduction-relation, (*a*) (probably chiefly by means of collaterals) with the nucleus nervi cochleæ ventralis; (*b*) (by means of ascending limbs of divided root fibres or collaterals from these) with the mass of nerve cells (Ramón y Cajal's nucleus cerebello-acusticus) in the lateral wall of the ventricle, dorsad to Bechterew's nucleus; and (*c*) with the nuclei of the roof of the fourth ventricle (nuclei fastigii) on both sides of the middle line, and (*d*) possibly, according to Cajal, by means of a few fibres with the nucleus dentatus cerebelli and the cerebellar cortex.

The topographical relations of these nuclei to one another and to the surrounding structures in the oblongata are shown in flat projection upon the horizontal plane in the accompanying figure (Fig. 428), after Miss Sabin. As seen in transverse section the relations are shown in Fig. 429, from Obersteiner. It should be noted that in this figure the letters *ND* stand in the position of the nucleus spinalis and the nucleus of Flechsig, as well as Deiters' nucleus. The secondary connections of the vestibular nuclei are exceedingly diverse and none too well known. Some of them are indicated in Fig. 429. We have seen above that a considerable number of direct root fibres enter the cerebellum, their connections there being largely problematical. It is, however, certain that a large proportion of the secondary fibres, especially those from the more lateral group of nuclei, pass into the cerebellum. Others reach a lateral vestibular bundle lying between the spinal fifth tract and the emerging fibres of the sixth nerve, some ascending and some descending in it. A considerable number of secondary fibres from both the medial and the lateral nuclei are known to enter the fasciculus longitudinalis medialis, some running cephalad, some caudad in this bundle. This is the chief path for reflexes to the oculomotor nuclei, and probably to the motor centres of the spinal cord as well. There are other descending and ascending paths less perfectly known, some of the latter undoubtedly entering the fillet.

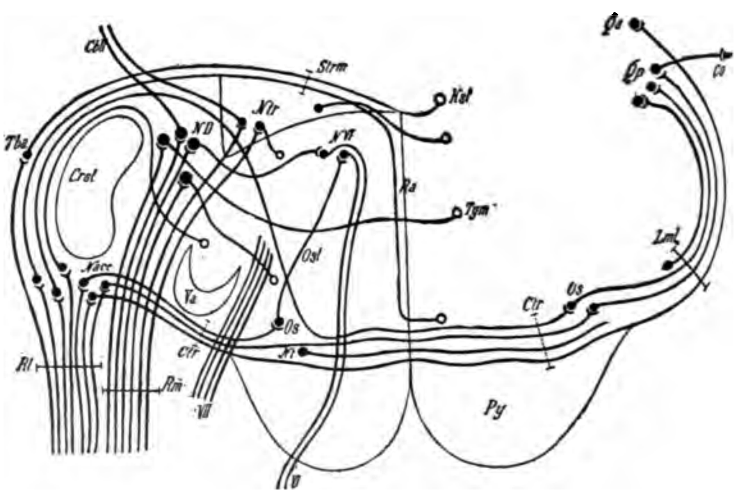
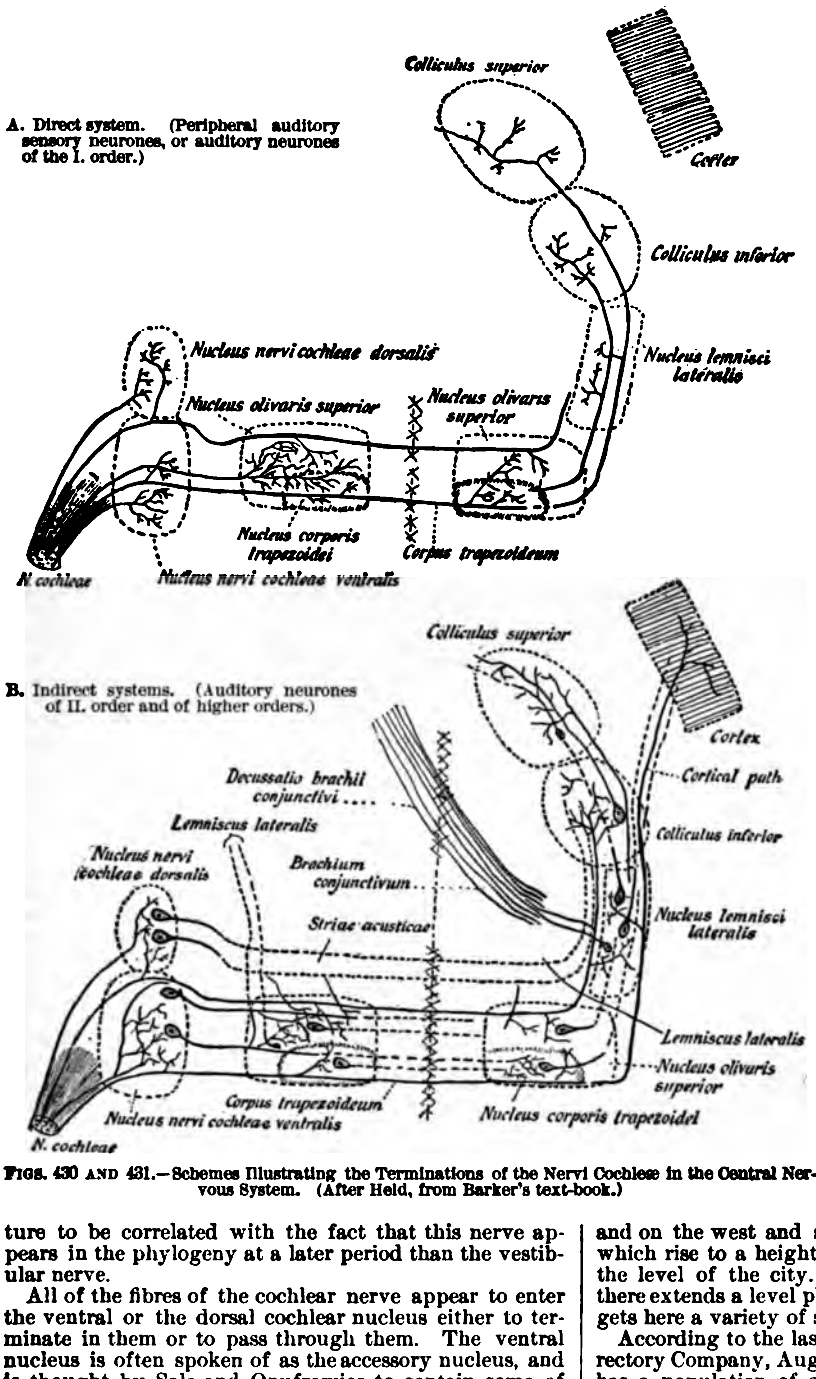


FIG. 429.—Schema of the Central Acoustic Apparatus. (After Obersteiner.) *Cbll*, Cerebellum; *Co*, cerebral cortex; *Crst*, corpus restiforme; *Ctr*, corpus trapezoides; *Kst*, conductor sonorus (*Klangstab*); *Lml*, lateral fillet; *Nacc*, nucleus accessorius (ventral cochlear nucleus); *ND*, Deiters' nucleus; *Nt*, trapezoid nucleus; *Ntr*, nucleus medialis (triangular nucleus); *N VI*, abducens nucleus; *Os*, superior olive; *Ost*, stalk of the superior olive; *Py*, pyramid; *Qa*, *Qp*, upper and lower corpora quadrigemina; *Ra*, raphe; *Rl*, lateral (cochlear) acusticus root; *Rm*, medial (vestibular) acusticus root; *Strm*, striæ medullares (striæ acusticæ); *Tba*, dorsal cochlear nucleus (tuberculum acusticum); *Tgm*, tegmentum; *Va*, spinal trigeminus root; *VI*, abducens root; *VII*, facialis root.

Cochlear Ramus.—The cell bodies from which the fibres of this nerve arise lie chiefly (if not wholly) in the spiral ganglion, or ganglion of Corti, in the axis of the bony cochlea. The peripheral processes of these ganglion cells (excluding the ramus medius of Schwalbe) terminate in the organ of Corti. The central processes constitute the cochlear (lateral or dorsal) auditory root. In the embryological development they become medullated somewhat later than those of the vestibular root, a feature to be correlated with the fact that this nerve appears in the phylogeny at a later period than the vestibular nerve.

All of the fibres of the cochlear nerve appear to enter the ventral or the dorsal cochlear nucleus either to terminate in them or to pass through them. The ventral nucleus is often spoken of as the accessory nucleus, and is thought by Sala and Onufrowics to contain some of the ganglion cells of the peripheral auditory neurones. The dorsal nucleus is the tuberculum acusticum of human anatomy. The fibres of the cochlear nerve bifurcate, upon entering the oblongata, into ascending and descending limbs. The ascending limbs generally enter the ventral cochlear nucleus, while the descending limbs may enter the dorsal cochlear nucleus.



FIGS. 430 AND 431.—Schemes Illustrating the Terminations of the Nervi Cochleæ in the Central Nervous System. (After Held, from Barker's text-book.)

The figures already given illustrate the relations of these terminal nuclei. The accompanying diagrams from Held (Figs. 430, 431) will serve in lieu of extended descriptions of their further connections. These are much too complicated to be given in detail here. The reader is referred to the extended review in Barker's recent textbook, "The Nervous System," chapter liv. In general terms, the central auditory path extends from the ventral nucleus, by way of the trapezoid body, and from the dorsal nucleus, by way of the striæ acusticæ (both root fibres and secondary fibres in each case), to the region of the superior olive, partly crossed and partly uncrossed. The path then goes by way of the lateral fillet to the inferior member of the corpora quadrigemina. This appears to be the general centre for the elaboration of the higher auditory reflexes, the reflex connections being very numerous, notably with lower centres and with the superior member of the corpora quadrigemina (optic reflex path). Cortical projection fibres also pass from this body viâ the brachium quadrigeminum inferius to the corpus geniculatum mediale. The path seems to be interrupted here and the fibres of the cortical acoustic path arise at this point, to terminate in the auditory sense area of the cortex; viz., according to Flechsig, "the two transverse gyri of the temporal lobe (particularly the anterior), and that portion of the gyrus temporalis superior immediately adjacent."

C. Judson Herrick.

AUGUSTA, Georgia (latitude, 32° 28′ N.; longitude, 81° 54′ W.), is located on the southwestern bank of the Savannah River, about 231 miles from its mouth. In an air line, or "as the crow flies," it is about 90 miles from the Atlantic coast. Its elevation above the sea level is 167 feet. Augusta proper is bounded on the north and northeast by the Savannah River, which separates the States of Georgia and South Carolina at this point; and on the west and southwest by a row of sand hills which rise to a height of from 298 feet to 350 feet above the level of the city. Toward the east and southeast there extends a level plateau of farming land, so that one gets here a variety of scenery of hill and vale and river.

According to the last census taken by the Maloney Directory Company, Augusta, with her immediate suburbs, has a population of about 63,000. The city proper is very level and has wide streets, the beauty of which have made her famed throughout the country. The main resident street—Greene Street—is 175 feet wide, and, for

more than two miles, has four rows of majestic elm and oak trees which make three avenues down the street. Between the two central rows of trees vehicles are not allowed to pass, this long path or green being reserved for pedestrians. A similar arrangement exists on upper and lower Broad Street, which is likewise 175 feet wide; but the middle portion is asphalted, and is the chief business street of the city.

The other streets are exceptionally wide, well fringed with beautiful shade trees, and nearly all of them are paved by a natural deposit, called "cement gravel," that is found in this section of the country. The formation used for paving purposes consists of clay, red sand, and pebbles varying in size from a split pea to a pigeon's egg. This makes a material for roadway purposes that can scarcely be excelled.

In addition to the river, which gives the city communication by boat with the up-country, Savannah and the intervening country, Augusta has no less than nine important railway lines, so that it is easy of access from any portion of the country; the roads centring in Augusta being the Atlantic Coast Line, Central of Georgia, Charleston and Western Carolina, Georgia, Port Royal, Seaboard Air Line, South Carolina, Southern, and Augusta Southern branch of the Southern Railway.

Augusta has about eighteen miles of electric railway, the cars of which run, upon convenient schedules, in various directions throughout the city. It has a well-conducted system of public schools, under which is included the Tubman High School for girls. The Richmond Academy for boys is an institution that was endowed by the crown of England; it celebrated its centennial more than a decade ago. A Jesuit college will be in operation in Augusta within a year. The Medical Department of the University of Georgia, now in the sixty-eighth year of its honorable and useful career, is also located here, so that visitors sojourning in Augusta for the winter may have ample educational advantages for their children. In addition to these, the city has a public library, a modern theatre building, and churches of all the more prominent denominations.

The Planters and the Commercial are the two hotels possessed by Augusta proper at this writing, but the contract has already been given out for a modern, up-to-date hotel of two hundred rooms, which is to be in operation by the autumn of the present year, and the plans for another are pretty well matured. There are also numerous boarding houses where one may obtain board at moderate rates.

Augusta takes its water supply from the Savannah River. There is no city located above it on the river, and a row of sand hills crosses the Savannah at this point. These hills make shoals in the river, and extend up it for a distance of forty miles, so that such impurities as may exist in the water have ample opportunity to be eliminated before the city is reached. Except for its burden of red clay, the water has been proven by the clinical experience of Augusta's physicians and by chemical analysis to be exceptionally free from impurities. To avoid all possible sources of contamination of its supply, the city has just completed the construction of a new system of water works, whereby its water is taken from the canal three miles above the city. The supply is forced into a reservoir on the hilltop, three hundred feet above the city, where it is filtered, and there delivered to the city water mains. Wells, pumps, and cesspools have been banished from the city by order of the Board of Health, until now only a few of the former and none of the latter remain within the city limits.

Augusta is honeycombed by an excellent system of sewers which thoroughly and quickly drain the city of sewage and storm water, and it is the writer's opinion that the remarkable healthfulness of the city is in large measure due to these and to its pure water supply. The soil of Augusta is largely made up of sandy loam, under which is a layer of sand and clay; and still deeper is encountered a layer of granite many hundred feet in thickness. The only artesian well in the city conducts its water through a stratum of granite that is 800 feet thick.

The healthfulness of Augusta is remarkable. The mortuary tables of the city show a steady decrease in the death rate from 1880, when the number of deaths per 1,000 inhabitants was 23.36, to 1898, when it was 16 per 1,000. The same decrease appears in certain specific cases: for example, the ratio of deaths to total mortality from typhoid fever in 1880 was 1 in 41.7, while in 1898 it was 1 in 133.6. Augusta is likewise exceptionally free from epidemic diseases. Yellow fever was epidemic in Augusta in 1839 and 1854. In both instances it was brought to the city, and an epidemic followed. Since then sporadic cases have been brought to the city, but in no instance has an epidemic succeeded; and for more than twenty years no case has occurred in the city. The absence of formidable outbreaks of measles, scarlet fever, diphtheria, and other epidemic diseases is doubtless due, in large measure, to the stringent sanitary regulations of the Board of Health,—but, in addition, to the fact that the city is not densely built up, each house, even in the poorer districts, having its little plot of land that separates it from its neighbor.

Augusta has a canal that takes its water from the Savannah River, seven miles above the city. This canal furnishes an enormous water power, making Augusta the greatest cotton-manufacturing centre in the South. The city owns the canal, and derives a handsome revenue from the water rents.

SUMMERVILLE, OR THE SAND HILLS.

The foregoing is largely introductory to the portion of Augusta that is known to and concerns the medical profession at large, inasmuch as the Augusta which has such a well-earned reputation as a health resort—the portion of the city that has almost exclusively attracted the attention of physicians—is Summerville, a suburb of Augusta.

In discussing the advantages and disadvantages of the place, it is not possible entirely to separate them, chiefly for the reason that the United States signal service bureau which furnishes the meteorological data is located down in the city, and not on the hilltop. It is well, therefore, to bear in mind that there is less humidity and some little difference in temperature in the portion of Augusta to which visitors and patients almost invariably go. The reason for this is that the city is 298 feet lower and borders on the river; and it is no uncommon sight to see a mist enveloping the city in the early morning while the hilltop is quite free from it.

In like manner the air in this region is more rarefied and purer than it is in the city, with its heavier atmosphere and denser population. Summerville, or the Sand Hills, on account of its healthfulness, was for many years called "Mount Salubrity." It is located on the crest of a row of sand hills which extend from Chester, S. C., down through Aiken, S. C., and which cross the Savannah River at Augusta, causing shoals in the river at that point, thereby making Augusta the head of navigation for the Savannah River. Summerville is an aristocratic suburb of Augusta, and for more than one hundred years many of the latter's wealthiest citizens have lived in quiet ease in this region. The border of the village touches that of Augusta, and the two are connected by an electric railway that runs, upon a fifteen-minute schedule, between the two places, making Summerville easy of access from any portion of the city. It is located at an elevation of 298 feet above the city, as stated, and from the crest of this sand ridge one can see many miles down over the plateaus on the Georgia side and far into South Carolina as well. It has a town marshal and town council; a new system of water works, electric lights, and a school—the Summerville Academy.

The soil, location, and climate of this village could hardly be excelled for healthfulness. It possesses, in my opinion, every advantage that Aiken does, being on the same ridge of hills, only a few feet lower, and has one advantage that Aiken has not—close proximity to a

city of 63,000 inhabitants, with all the attractions for cultivation, amusement, and shopping that such a city can give. It also has an advantage over many of the resorts farther south, inasmuch as its climate, though colder, is still not too cold for out-of-door life, and its air is not so depressing. The top soil of the region is almost entirely sand, and for this reason the chief vegetation consists of pines, oaks—many of the scrub-oak variety—and such grasses as will grow on a dry, sandy soil.

In all seasons of the year this region is attractive, for the pines are perennially green, and in the springtime the land blossoms like the rose. Wild flowers grow in profusion, and the odor of the yellow jasmine which clambers over the scrub oaks, the honeysuckle, and the wild shrub, mingling with the balsamic odor of the pines, makes the region exceedingly attractive for either temporary or permanent residence.

The sandy nature of the soil makes the hilltop like a great filter; the rain water quickly passes down into the deeper strata, and the altitude of the place causes the water to run off rapidly into the lower-lying plateaus. Under the sand is a soil made up of red sand and clay, and under this is a stratum of granite many hundred feet in thickness, so that it is impossible for water to accumulate in the region. Within a few hours after the heaviest rain it is possible to go out into the open air and walk for miles without getting the feet wet. As an evidence of the depth of this top stratum of sand, it may be mentioned that in the sinking of wells, which were used exclusively for domestic purposes before the advent of the new system of water works, it was found necessary to go down to a depth of from 80 to 150 or 200 feet before striking water. The great depth of this porous soil and the altitude of the place make bad drainage almost an impossibility, and as a matter of fact I have never detected a noisome odor that could be traced to defective sewerage in any portion of Summerville.

Located as it is, on the summit of a sand ridge, away from the noise and bustle of the city, with its beautiful sweep of landscape, taking in hill and valley, and the sinuous outline of the broad Savannah as it courses toward the sea, with perfect drainage, rarefied and invigorating air, Summerville is, as might be expected, valued alike by the resident of the region and the stranger within its gates.

Among the attractions outside of these natural advantages may be mentioned the splendid system of roadways that extend in every direction throughout Richmond County. These roads are constructed by convict labor, and are made of cement gravel, which packs down as level as a floor. The roads do not cut up in wet weather, nor do they ever get excessively dusty; and I have never seen roads to excel them for riding, driving, bicycling, and walking. Some such paving was a necessity, because our sand roads are naturally so heavy that travelling over them is both unpleasant and difficult.

The Bon Air Hotel, accommodating 250 people, is located on the crest of the hill overlooking the city and the highlands in South Carolina. This hotel has been in operation for ten years, and it is the universal verdict of competent judges who have travelled throughout the South that it is the best-kept hotel this side of New York City. So popular has this hotel grown that it is impossible to obtain accommodations therein after February 1st unless arrangements are made several weeks in advance. The hotel is handsomely furnished throughout, having billiard and pool rooms, bowling alleys, etc. The Bon Air Golf Club has a fine course of 18 holes, and is 2,900 feet long. This furnishes open-air exercise and amusement for the guests of the hotel, and for many of the residents of Summerville and Augusta as well. In Summerville there are several first-class boarding houses, and a number of private families who take a few boarders each season. In these the price of board is, of course, cheaper and the life quieter than at the hotel. Such accommodations suit both those of modest means and those whose means are ample but who dislike hotel life. There are also a number of new and comfortable cottages, equipped with water from the city works and possessing modern conveniences, that may be had for a reasonable rental.

Game is plentiful around Augusta, and even to the stranger tourist the farmers are generous in allowing access to their hunting preserves. There is an excellent livery service in connection with the Bon Air Hotel, and the proximity of the city, with its large number of livery stables, makes riding and driving over the splendid roads a pleasurable pastime.

Summerville has a population of from 2,000 to 3,000 people. As an evidence of the healthfulness of this village, it may be mentioned that during the four years from 1864 to 1868, only fourteen deaths occurred. "Six of these ranged from 70 to 102 years. Two deaths were from accident, one from pseudo-croup, two from congestive fever contracted elsewhere and neglected, one from pneumonia contracted elsewhere and neglected, one from congestion of the brain, one from ascites, one from tuberculosis contracted elsewhere." Unfortunately, no mortuary records of the village of Summerville have ever been kept, but the death rate is very low. During last winter the Government established Camp McKenzie at Monte Sano, a portion of Summerville. There were between 7,000 and 8,000 troops encamped there during the winter and spring months, and it was the general verdict of the medical officers that this was the healthiest camp in the country. The War Office has not published the statistics of mortality and sickness at the camps as yet, but when it does, I am satisfied that the figures will verify this.

The United States has for many years maintained an arsenal on the summit of the hilltop, and during the years 1849 to 1869 meteorological observations were taken at sunrise, 9 A.M., 3 P.M., and 9 P.M. The observations extending over this period of twenty years are as follows:

Mean average temperature for January, 46.7° F.; February, 50.7° F.; March, 58.8° F.; April, 65.1° F.; May, 72.2° F.; June, 80.9° F.; August, 79.7° F.; September, 72.8° F; October, 63.5° F.; summer, 79.9° F.; autumn, 63.4° F.; winter, 47.9° F.

The mean annual rainfall for the same period was: spring, 37.17 inches; summer, 14.14 inches; autumn, 6.95 inches; winter, 5.92 inches. Mean number of fair days per year 238; cloudy days, 70; rainy days, 57; snow about two days to every three years.

Prevailing winds: spring, northwest and southeast; summer, south and southwest; autumn, north, northwest, and southwest; winter, south, southwest, west, northwest, and north.

Unfortunately, no record of the humidity of the atmosphere was taken, and it cannot be obtained now—the humidity in the annexed table being for Augusta, located 298 feet below and contiguous to the river. But considering the proximity of Summerville to Aiken (only 16 miles), and the similarity of soil and elevation, I do not believe that the humidity of the former differs from that of the latter to any appreciable extent.

In a pamphlet by Dr. C. J. Kenworthy, on the "Climate of Florida," the fact is noted that Augusta, Ga., has a mean temperature, for the months of November, December, January, February, and March, of 51.4° F., while that of Cannes is 50.8° F. Again the interesting fact is shown that Augusta has a mean relative humidity for these months 2.5 degrees less than that of Cannes or Mentone, and one-tenth of a degree more than that of Jacksonville, Fla.

The accompanying table of the U. S. weather bureau located at Augusta, covering a period of twenty-nine years, was furnished through the kindness of the signal service officer at the point, Sergeant Fisher. By consulting the table it will be seen that the average number of clear days and partly clear days for the twenty-nine years was: for December, 21; January, 20; February, 18; March, 23, and April, 23. With such an average extending over so great a number of years, it is easy to see that one can spend much time in comfort out of doors when it would be impossible to do so in the more rigorous northern climates.

CLIMATE OF AUGUSTA, GEORGIA, LATITUDE, 32° 28′ N.; LONGITUDE, 81° 54′ W.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Temperature:												
Average or normal for 29 years	47	50	56	64	73	79	81	79	75	64	54	48
Average daily range for 20 years	18.1°	19.4°	21.4°	22.°	21.9°	19.9°	19°	18.8°	18.5°	20.8°	20.7°	19.5°
Mean of warmest for 29 years	56	58	62	69	77	83	85	84	79	71	60	57
Mean of coldest for 29 years	39	38	50	59	69	74	78	76	70	58	48	38
Highest or maximum for 29 years	80	84	89	93	100	108	105	105	101	94	85	78
Lowest or minimum for 29 years	6	3	22	29	41	46	57	58	41	29	23	7
Average date of last killing frost for 2	9 years,	March 1	8th.									
Average date of first killing frost for 2	9 years,	Novemb	er 8th.									
Humidity:												
Average relative for 5 years	74	71	70	66	66	70	76	80	74	74	78	76
Average absolute for 5 years	2.457	2.550	3.414	3.936	5.555	7.441	7.980	8.240	6.563	4.372	3.539	2.366
Precipitation:												
Average in inches for 29 years	4.35	4.30	4.97	3.48	3.28	4.50	5.52	5.27	3.80	2.42	3.08	3.36
Wind:												
Prevailing direction for 29 years	W.	W.	W.	W.	S.E.	S.	S.E.	N.E.	N.E.	N.E.	N.E.	W.
Average velocity in miles per hour	4.5	7.0	7.0	6.5	5.8	5.4	5.1	5.0	5.2	6.2	5.5	6.0
Weather:												
Average number clear and fair days for 5 years	20	18	22	23	25	23	23	23	23	25	22	21
Largest number clear days for 5 years	19	23	22	25	28	29	26	26	27	27	25	24
Smallest number clear days for 5 years	16	14	12	22	22	23	19	18	21	21	19	19
Average number cloudy days for 5 years	11	10	9	7	6	7	8	8	7	6	8	10
Largest number cloudy days for 5 years	15	14	19	8	9	7	12	13	9	10	11	12
Smallest number cloudy days for 5 years	12	5	9	5	3	1	5	5	3	4	5	7
Average number rainy days for 29 years	11	10	10	8	8	11	12	13	7	7	8	9
Smallest number rainy days for 5 years	7	2	9	7	3	6	8	10	5	2	5	6
Largest number rainy days for 5 years	13	14	15	11	13	15	13	19	8	8	13	11

The temperature, in the winter months, not infrequently drops below the freezing point and thin ice is formed, but the changes are not usually abrupt and the cold does not continue long. Only once, in thirty-five years' experience, have I known the mercury to register as low as 5° above zero. The climate of Augusta may be summarized as moderately dry, mild, and equable.

Dr. Richards, in an article in the first edition of this work, calls attention to the fact that the census for 1880 shows the percentage of deaths from consumption to be, for Georgia, 11.14 per 10,000 inhabitants; and the eleventh census shows a similarly small death rate for this disease. Rheumatic and asthmatic cases almost invariably do well here. Its lower altitude makes this region superior to Denver for cardiac cases and tuberculous cases complicated by heart lesions; and it is superior to Florida in that the climate is less debilitating.

When I began the practice of medicine here, I was struck with the comparative rarity of renal diseases, and a riper experience confirms my first observation. This may be explained, in my opinion, by the freestone drinking water, the simplicity of living, and the equable temperature. Be the explanation what it may, it is a fact that renal diseases are comparatively infrequent, and that cases of this class are benefited when brought here, unless the disease has already so far advanced that relief is impossible.

Thomas D. Coleman.

AURICLE, ANATOMY AND PHYSIOLOGY OF.—The auricle or pinna forms with the auditory canal or meatus the external ear. It is placed on the side of the head about midway between the external angle of the eye and the occipital protuberance; the upper border is about on a level with the eyebrow; the lower edge of the lobe is about on a level with the tip of the nose. Its vertical line is parallel to the ramus of the jaw and forms an angle of about 100 or 105 degrees with the horizontal plane of the head. Those ears in which this angle exceeds 112 degrees are called slanting ears. In height the auricle measures from 55 to 60 mm., and in width from 25 to 35 mm. The height of the auricle is generally found to be equal to the length of the nose. The true length of the auricle varies in man from 22 to 49 mm., the average being 35.9 mm.; in woman it varies from 24 to 41 mm., the average being 33.7 mm. The true width * of the auricle varies in man from 33 to 58 mm., the average being 44.4 mm., while in woman it varies from 30 to 61 mm., the average being 40 mm. The anterior third of the auricle is firmly attached to the root of the zygoma and to the squamous and mastoid surfaces of the temporal bone by means of ligamentous, muscular, and cutaneous tissues. The posterior two-thirds is free and is placed so as to form with the lateral surface of the head the cephalo-auricular angle which, opening backward, measures on an average from 30 to 40 degrees, and may vary between 0 and 90 degrees; the angle decreasing in size as it passes upward and forward.

The *framework* of the auricle consists of convoluted folds of yellow reticulated cartilage, from 1 to 2 mm. in thickness, and is covered by its perichondrium. It supports the glandular, vascular, muscular, and cutaneous tissues of the auricle. The cartilage does not enter into the construction of the lobule and is deficient between the tragus and the spina helicis.

The auricle may be considered to be an expansion of the external auditory canal, which it surrounds, and especially so above and behind. It is oval in form, with the longest axis vertical and its broadest extremity above. It has two surfaces—an external and an internal—and a circumferential border. The external surface looks obliquely outward, forward, and slightly downward. It is so folded upon itself that it presents a number of elevations and depressions, which give it a most irregular and characteristic appearance. The outer surface is as a whole concave, while the inner is convex, and the depressions and elevations of one surface correspond in a general way to the elevations and depressions of the other.

The border of the auricle—that is, the upper third of the anterior portion, all of the superior portion, and the upper two-thirds of the posterior portion—is rolled in upon itself and forms the most prominent elevation or crest on the external surface of the organ. It is called the *helix* (Fig. 432, 1, 2, 3). It begins in a thin root, the *crus helicis* (Fig. 432, 1), in the cavity of the concha, and passes obliquely upward and forward, and then in a semicircle upward, backward, and downward, to terminate in a free extremity, the *processus helicis caudatus* (Fig. 433, 2), at the *sulcus helicolobularis* (Fig. 432, 15). The *crista helicis* divides the concha into two parts—the upper and smaller, the *cymba conchæ* (Fig. 432, 19), and the lower and larger, the *cavitas conchæ* (Fig. 432, 20), which is continuous with the external auditory canal. By the incurving of the helix a groove is formed beneath it—the *fossa of the helix*. This groove is well marked in its ascending portion, and gradually becomes shallow as

* The terms "true length" and "true width" are explained further on.

it passes backward, and downward. A small spine, the *spina helicis* (Fig. 433, 1), is given off from the ascending portion of the helix. It serves to give a firm attachment to the attrahens auriculum muscle. This spine, as well as the *processus caudatus helicis*, is only to be seen when the cartilage is denuded of its coverings. At the junction of the horizontal portion of the helix with the descending portion we have a tubercle known as the *Darwinian Point* or *Tubercle* (Fig. 432, *c*), which possesses much morphological importance, as will be shown below. It corresponds to the ear tip of animals.

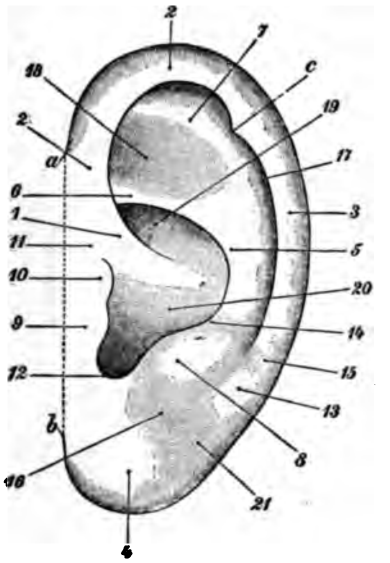


FIG. 432.—Auricle of a Man. (After Schwalbe.) *ab*, Base of the auricle; *abc*, triangle of the auricle; *c*, Darwinian point or tubercle; 1, crus helicis; 2, 2, ascending (anterior upper) portion of the helix; 3, descending (posterior) portion of the helix; 4, lobule; 5, main portion of the antihelix; 6, crus inferius anthelicis; 7, crus superius anthelicis; 8, antitragus; 9, tragus; 10, tuberculum supratragicum; 11, sulcus auris anterior (incisura trago-helicina); 12, incisura intertragica; 13, tuberculum retrolobulare of His; 14, sulcus auris posterior (incisura anthelicis); 15, sulcus helicolobularis; 14+15, sulcus obliquus of His; 16, sulcus supralobularis; 17, fossa navicularis or scaphoidea; 18, fossa triangularis; 19, cymba conchæ; 20, cavitas conchæ; 21, sulcus retrolobularis.

A second eminence or crest, the *antihelix* (Fig. 432, 5), begins, in the upper anterior portion of the fossa helicis, in two converging crests, the *crura furcata*, or the *crus inferius anthelicis* (Fig. 432, 6), and the *crus superius anthelicis* (Fig. 432, 7). It passes downward and backward in front of the descending portion of the helix. The depression which is formed between the two crests is known as the *fossa navicularis* or *fossa scaphoidea* (Fig. 432, 17). The depression between the crura furcata is called the *fossa intercruralis* or *triangularis* (Fig. 432, 18). The antihelix is separated, by the sulcus auris posterior (incisura anthelicis, Fig. 432, 14), from a rounded eminence—the *antitragus* (Fig. 432, 8),—and in front of this eminence, and separated from it by that portion of the cavity of the concha which is called the *incisura intertragica* (Fig. 432, 12), is a lid-like covering to the auditory canal—the *tragus* (Fig. 432, 9). It is separated from the root of the helix by the *sulcus auris anterior* or *incisura tragohelicina* (Fig. 432, 11).

The most dependent part of the auricle, which is devoid of cartilage and is made up principally of connective and adipose tissues, is called the *lobe* (*lobulus auricularis*) (Fig. 432, 4).

On the inner surface the elevations, as they correspond to the depressions on the outer surface, have received similar names, and are known consequently as the *eminentia fossæ scaphoideæ vel triangularis* (Fig. 433, 7); the *eminentia fossæ navicularis* (Fig. 433, 11); and the *eminentia conchæ* (Fig. 433, 8). From the posterior inferior border of the latter eminence arises a crest, the *ponticulus* (Fig. 433, 10), which passes obliquely downward and forward to the *incisura terminalis* (Fig. 433, 12); and to this crest is attached the retrahens auriculum muscle.

In a like manner the following names have been given to the depressions on the inner aspect of the auricle: the *fossa anthelicis*, (Fig. 433, 5); the *sulcus anthelicis transversus* (Fig. 433, 6); the *sulcus cruris helicis* (Fig. 433, 9); and the *fissura antitrago-helicina* (Fig. 433, 13).

To aid in holding the cartilaginous folds in place and in uniting the auricle to the head, two sets of *ligaments* are provided—the intrinsic and the extrinsic.

The *intrinsic ligaments* are four in number: two are on the inner surface of the auricle and unite the eminentia conchæ with the eminentia triangularis, and also with the eminentia fossa navicularis. The other two are on the outer surface. One unites the antitragus with the processus caudatus helicis and the antihelix, and so fills in the sulcus auris posterior. The fourth extends from the tragus to the helix, and gives off a fasciculus which is inserted in the external auditory canal. It in great measure fills up the incisura intertragica.

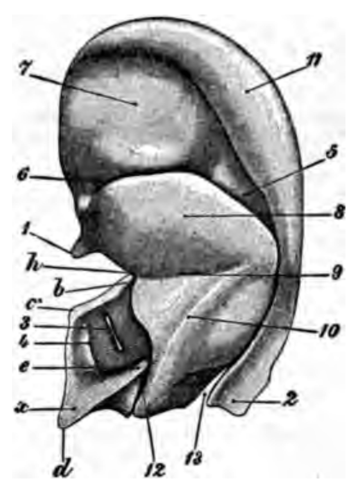


FIG. 433.—Cartilaginous Framework of the Human Auricle (Inner Surface). (After Schwalbe.) *bc*, Upper border of the cartilaginous furrow for the blood-vessels; *cd*, anterior medial border; *de*, posterior medial border; *x*, processus triangularis; *h*, angle of the anterior margin of the concha; 1, spina helicis; 2, processus helicis caudatus; 3, lateral bipartite Santorinian incisura; 4, medial Santorinian incisura; 5, fossa anthelicis; 6, sulcus anthelicis transversus; 7, eminentia fossæ triangularis; 8, eminentia conchæ; 9, sulcus cruris helicis; 10, ponticulus; 11, eminentia fossæ navicularis; 12, incisura terminalis; 13, fissura antitrago-helicina.

The *extrinsic ligaments* are: the anterior, divided into a superior and an inferior fasciculus, which extend from the root of the zygoma to the tragus and to the spina helicis; the posterior, which extends from the mastoid process to the posterior surface of the concha; and, finally, a fasciculus which extends into the external auditory canal.

FIG. 434.—Muscles of the Auricle as Seen on the External Surface.

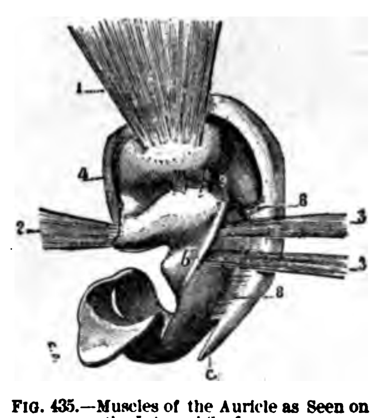


FIG. 435.—Muscles of the Auricle as Seen on the Internal Surface.

FIGS. 434 AND 435.—1, The attolens auriculum or musculus auricularis superior; 2, the attrahens auriculum or musculus auricularis anterior; 3, 3, the retrahens auriculum, or musculus auricularis posterior; 4, the helicis major; 5, the helicis minor; 6, the tragicus, with 6′, its accessory fasciculus; 7, the antitragicus; 8, the transversus auricular; 9, the obliquus auriculæ; *a*, spina helicis; *b*, concha, with *b′* its posterior thickening or ponticule; *c*, spina caudatus helicis. (After Testut.)

it passes backward, and downward. A small spine, the *spina helicis* (Fig. 433, 1), is given off from the ascending portion of the helix. It serves to give a firm attachment to the attrahens auriculum muscle. This spine, as well as the *processus caudatus helicis*, is only to be seen when the cartilage is denuded of its coverings. At the junction of the horizontal portion of the helix with the descending portion we have a tubercle known as the *Darwinian Point* or *Tubercle* (Fig. 432, *c*), which possesses much morphological importance, as will be shown below. It corresponds to the ear tip of animals.

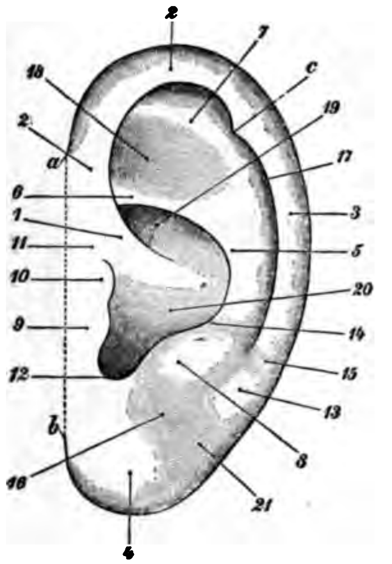


FIG. 432.—Auricle of a Man. (After Schwalbe.) *ab*, Base of the auricle; *abc*, triangle of the auricle; *c*, Darwinian point or tubercle; 1, crus helicis; 2, 2, ascending (anterior upper) portion of the helix; 3, descending (posterior) portion of the helix; 4, lobule; 5, main portion of the antihelix; 6, crus inferius anthelicis; 7, crus superius anthelicis; 8, antitragus; 9, tragus; 10, tuberculum supratragicum; 11, sulcus auris anterior (incisura trago-helicina); 12, incisura intertragica; 13, tuberculum retrolobulare of His; 14, sulcus auris posterior (incisura anthelicis); 15, sulcus helicolobularis; 14 + 15, sulcus obliquus of His; 16, sulcus supralobularis; 17, fossa navicularis or scaphoidea; 18, fossa triangularis; 19, cymba conchæ; 20, cavitas conchæ; 21, sulcus retrolobularis.

A second eminence or crest, the *antihelix* (Fig. 432, 5), begins, in the upper anterior portion of the fossa helicis, in two converging crests, the *crura furcata*, or the *crus inferius anthelicis* (Fig. 432, 6), and the *crus superius anthelicis* (Fig. 432, 7). It passes downward and backward in front of the descending portion of the helix. The depression which is formed between the two crests is known as the *fossa navicularis* or *fossa scaphoidea* (Fig. 432, 17). The depression between the crura furcata is called the *fossa intercruralis* or *triangularis* (Fig. 432, 18). The antihelix is separated, by the sulcus auris posterior (incisura anthelicis, Fig. 432, 14), from a rounded eminence—the *antitragus* (Fig. 432, 8),—and in front of this eminence, and separated from it by that portion of the cavity of the concha which is called the *incisura intertragica* (Fig. 432, 12), is a lid-like covering to the auditory canal—the *tragus* (Fig. 432, 9). It is separated from the root of the helix by the *sulcus auris anterior* or *incisura tragohelicina* (Fig. 432, 11).

The most dependent part of the auricle, which is devoid of cartilage and is made up principally of connective and adipose tissues, is called the *lobe* (*lobulus auricularis*) (Fig. 432, 4).

On the inner surface the elevations, as they correspond to the depressions on the outer surface, have received similar names, and are known consequently as the *eminentia fossæ scaphoideæ vel triangularis* (Fig. 433, 7); the *eminentia fossæ navicularis* (Fig. 433, 11); and the *eminentia conchæ* (Fig. 433, 8). From the posterior inferior border of the latter eminence arises a crest, the *ponticulus* (Fig. 433, 10), which passes obliquely downward and forward to the *incisura terminalis* (Fig. 433, 12); and to this crest is attached the retrahens auriculum muscle.

In a like manner the following names have been given to the depressions on the inner aspect of the auricle: the *fossa anthelicis*, (Fig. 433, 5); the *sulcus anthelicis transversus* (Fig. 433, 6); the *sulcus cruris helicis* (Fig. 433, 9); and the *fissura antitrago-helicina* (Fig. 433, 13).

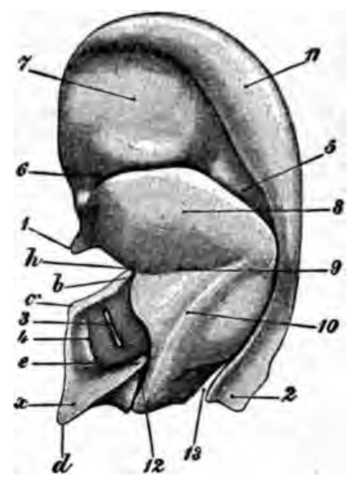


FIG. 433.—Cartilaginous Framework of the Human Auricle (Inner Surface). (After Schwalbe.) *bc*, Upper border of the cartilaginous furrow for the blood-vessels; *cd*, anterior medial border; *de*, posterior medial border; *x*, processus triangularis; *h*, angle of the anterior margin of the concha; 1, spina helicis; 2, processus helicis caudatus; 3, lateral bipartite Santorinian incisura; 4, medial Santorinian incisura; 5, fossa anthelicis; 6, sulcus anthelicis transversus; 7, eminentia fossæ triangularis; 8, eminentia conchæ; 9, sulcus cruris helicis; 10, ponticulus; 11, eminentia fossæ navicularis; 12, incisura terminalis; 13, fissura antitrago-helicina.

To aid in holding the cartilaginous folds in place and in uniting the auricle to the head, two sets of *ligaments* are provided—the intrinsic and the extrinsic.

The *intrinsic ligaments* are four in number: two are on the inner surface of the auricle and unite the eminentia conchæ with the eminentia triangularis, and also with the eminentia fossa navicularis. The other two are on the outer surface. One unites the antitragus with the processus caudatus helicis and the antihelix, and so fills in the sulcus auris posterior. The fourth extends from the tragus to the helix, and gives off a fasciculus which is inserted in the external auditory canal. It in great measure fills up the incisura intertragica.

The *extrinsic ligaments* are: the anterior, divided into a superior and an inferior fasciculus, which extend from the root of the zygoma to the tragus and to the spina helicis; the posterior, which extends from the mastoid process to the posterior surface of the concha; and, finally, a fasciculus which extends into the external auditory canal.

FIG. 434.—Muscles of the Auricle as Seen on the External Surface.

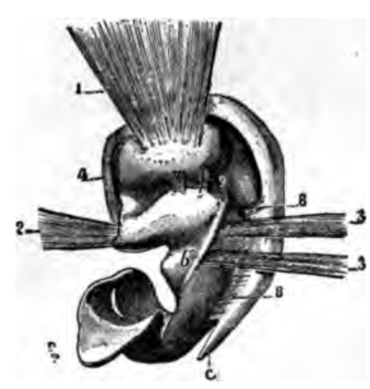


FIG. 435.—Muscles of the Auricle as Seen on the Internal Surface.

FIGS. 434 AND 435.—1, The attolens auriculum or musculus auricularis superior; 2, the attrahens auriculum or musculus auricularis anterior; 3, 3, the retrahens auriculum, or musculus auricularis posterior; 4, the helicis major; 5, the helicis minor; 6, the tragicus, with 6′, its accessory fasciculus; 7, the antitragicus; 8, the transversus auricular; 9, the obliquus auriculæ; *a*, spina helicis; *b*, concha, with *b′* its posterior thickening or ponticule; *c*, spina caudatus helicis. (After Testut.)

The *muscles* of the auricle are also divided into the intrinsic and the extrinsic group. The first group consists of: I., the *helicis major* (Fig. 434, 4), which extends from the spina helicis to the ascending portion of the helix and the integument covering it; II., the *helicis minor* (Fig. 434, 5), which extends from the root of the helix to the ascending portion of the helix; III., the *tragicus*, a quadrilateral bundle of fibres attached to the external surface of the tragus by two sets of fibres—one of them running laterally and another vertically, while a small bundle of the latter extends to the spina helicis (Fig. 434, 6, 6′); IV., the *antitragicus*, which passes from the antitragus upward and backward to the antihelix and the helix near the spina caudatus helicis (Fig. 434, 7); V., the *transversus auriculæ*, which extends on the inner surface of the auricle from the lower portion of the eminentia navicularis to the eminentia conchæ (Fig. 435, 8); VI., the *obliquus auriculæ*, which consists of two or three fasciculi and extends from the eminentia fossæ triangularis to the eminentia conchæ (Fig. 453, 9).

In man these muscles are merely rudimentary, while in animals they serve, first, to modify the general form of the auricle so as to allow, at pleasure, the manner and the amount of force with which the sound waves are reflected toward the auditory canal; second, to modify the dimensions of the entrance to the auditory canal, so as to influence the amount of sound which is to penetrate to the membrana tympani. The muscles of the tragus and the antitragus are the constrictors, and the muscles of the helix are the dilators, of the external auditory canal.

The second or extrinsic group of muscles of the auricle are: I., the *attollens auriculum*, or *musculus auricularis superior*, which arises from the epicranial aponeurosis, passes downward and with fibres converging, and is inserted into the eminentia triangularis (Figs. 434, 435, 1); II., the *attrahens auriculum*, or *musculus auricularis anterior*, which also arises from the cranial aponeurosis above the zygoma, passes backward, and is inserted into the spina helicis (Figs. 434, 435, 2); III., the *retrahens auriculum*, or *musculus auricularis posterior*—a muscle which is composed of two or three fasciculi that arise from the mastoid process, pass forward, and are then inserted into the ponticulus (Figs. 434, 435, 3). These muscles are also for the most part rudimentary in man, but, when they are capable of voluntary action, the first draws the auricle upward, the second forward and upward, and the third backward. In animals these muscles serve the important function of directing the auricles toward the source of the sound.

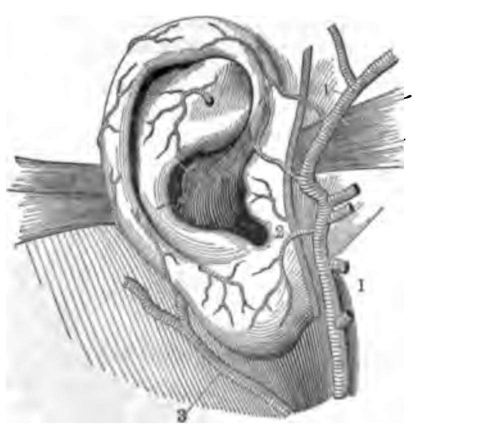


FIG. 436.—Arteries of the Auricle. 1, The superficial temporal; 2, inferior anterior auricular branch; 3, posterior auricular. (After Testut.)

The *skin* which covers the auricle, except for its greater delicacy is of the same general construction as that of the surrounding region, with which it is continuous. Owing to a greater development of its subcutaneous connective tissue on the external surface of the auricle, it is more firmly attached to it than on the inner surface. Except in the lobe of the ear it is destitute of fat; on the other hand, it is well supplied with lymphatics, especially so on its inner surface. The *sebaceous glands* scattered over the surfaces of the auricle are found more numerous in the concha and in the fossa triangularis. *Sudoriferous glands* are also to be found on the surfaces of the auricle.

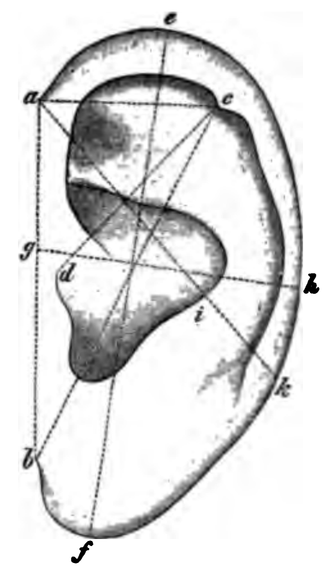


FIG. 437.—Diagram of the Human Auricle, Showing Its Chief Dimensions. (After Schwalbe.) *ab*, Base of the auricle, true breadth; *cd*, true length of the auricle; *ef*, maximum length; *gh*, maximum breadth; *acb*, triangle of the auricle. The line *ak*, is the dividing line between the region of the auricular eminences (*aikfb*) and that of the free fold (*aikcc*).

The *arteries* which supply the auricle are derived from the superficial temporal (Fig. 436, 1), and the posterior auricular (Fig. 436, 3), both of them branches of the external carotid. From the first are derived the *superior anterior*, the *middle anterior*, and the *inferior anterior auricular* branches, which supply the anterior portion of the external surface of the auricle (Fig. 436, 2). From the second are derived the *posterior auricular* branches, three or four in number, which supply the posterior two thirds of the auricle, both on its inner and on its outer surface. These arteries are divided into two sets of branches, one set of which pass superficially on the inner surface of the auricle to its border and thence over it to the outer surface, while the other set penetrate through from the inner surface to the outer and furnish the blood supply for the structures of the concha, the antihelix, and the lobule (Fig. 432, 4, 5). Free anastomosis takes place between all of these various branches.

The surface of the auricle is almost everywhere covered with fine soft lanugo hairs, but in the region of the meatus and of the tragus and antitragus, there are apt to be—especially later in life—some very stiff and wiry hairs.

The *nerves* are of two kinds, the sensory and the motor: the latter being derived from the facial and the former from the auricular temporal branch of the inferior maxillary, and also from the temporo-auricular branch of the superficial cervical plexus.

The TRUE AURICLE is to be found only in the mammalia. The movable fold of skin which covers the opening to the auditory canal of such animals as the crocodile is by no means homologous with the auricle of the mammalia; a greater likeness is to be seen in the movable flap of skin to be found in such birds as the owl. On the other hand, the auricle of *man* is but poorly developed when compared with that of most animals, *e.g.*, the kangaroo, the rabbit, the hare, the carnivora, in all of which the auricle is very highly developed, while in the long-eared bat of Britain the surfaces of both auricles are together equal to the entire surface of the rest of the body exclusive of the wings.

To make a comparison between the auricles of man and those of animals it is necessary to have certain fixed points as a means for such comparison. For this purpose we take the true tip of the auricle (Fig. 437, *c*) for one point, and the extremities of the base of the auricle, which corresponds to the front line of its insertion, for two other points (Fig. 437, *a*, *b*). The triangle formed by

joining these points (Fig. 437, *a, c, b*) is designated by Schwalbe as the auricular triangle, and is the foundation for comparison between the auricles of all the mammalia. A straight line drawn from the true tip of the auricle (Fig. 437, *c*) to the incisura auris anterior (Fig. 437, *d*)

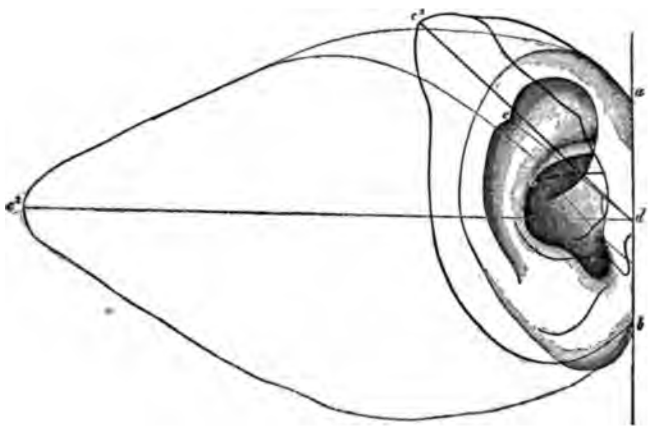


FIG. 438.—The Human Auricle and Those of the Cynocephalus (a Species of Ape) and the Ox, So Arranged as to Show Their Relative Sizes and Shapes. (After Schwalbe.) *acb*, Auricle of the human being (drawn in detail); ac^1b, that of the ape (drawn simply in black outline); ac^2b, that of the ox (drawn in dotted outline); *dc*, dc^1, dc^2 represent the relative lengths of the three auricles.

strikes the basal line of the auricle close above the tragus; the distance between these two points being the true length of the auricle, while the distance between the two extremities of the basal line of the auricle is its true breadth. That this is the correct index for measurement is seen at once when the auricle of man is compared with that of the baboon and of the ox, by superimposing the outline drawings of the reduced auricles of these

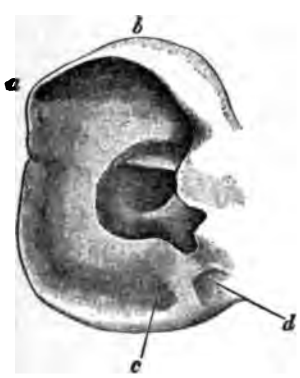


FIG. 439.—Auricle of Cercopithecus Cynosurus. (After Schwalbe.) *a*, True auricular tip; *b*, highest point of auricle; *c*, lower end of the fossa navicularis; *d*, area lobularis; between c and d there is a rounded eminence which springs, on one side, from the cartilaginous cauda helicis and extends to the antitragus.

FIG. 440.—Left Auricle of a Chimpanzee. (After Schwalbe.) In the vicinity of the antitragus and the cartilaginous cauda helicis the skin has been removed. At this point the cartilage of the antitragus, the musculus antitragicus and the cauda helicis, can be seen. 1, Tubercle of Darwin's auricular tip: 2, crus anthelicis tertium; 3, lobule; 4, cauda helicis; 5, musculus antitragicus. (Reduced in size.)

over that of the human auricle, in such a manner that the basal line or true breadth of the auricle of all three will be of the same size (Fig. 438). The distance between the two points (c^2–*d*) is the true length of the auricle of the ox and is extraordinarily greater than that of the baboon (c^1–*d*), which is itself much larger than that of the human auricle (*c*–*d*). However, this noticeable reduction in length is not true of some other measurements. This can be demonstrated if the straight line (Fig. 437, *a–i–k*) be drawn from the upper insertion point of the auricle to the sulcus auris posterior, at about a right angle to the line which represents the true length of the auricle. The first line divides the auricle into an upper or apical region, and a lower or basal region. The latter (Fig. 437, *a, i, k, f, b*) is designated by Schwalbe as the region of eminences or the conservative portion, and the former (Fig. 437, *a, i, k, c, e*) as the free auricular fold, or the variable portion. In the ape and especially in man the conservative portion is well marked, while in the majority of all other mammalia it is drawn into the funnel-shaped entrance of the external auditory canal.

It is in the apical portion of the auricle of man that the greatest change occurs. First, there is the marked involution of the free border of the ear in the formation of the helix. In animals only the beginning of the helix is involuted and the auricular tip occupies its highest point. In the higher order of apes the incurving of the helix is completed as far as the tip of the auricle, and in the genus cercopithicus the auricular tip is moved down on the posterior auricular border (Fig. 439, *a*), while in the chimpanzee (Fig. 440) we find a beginning involution of this border. Second, the development of the crus superius anthelicis is connected with the progressive diminution of the human auricle, for if the human auricle is compared with that of the lemur, we find, in the latter, that of the entire antihelix system, only the crus anthelicis inferius (Fig. 441, *b*) and the very lowest part of the antihelix (Fig. 441, *c*) are developed. This last part is an extension of the antitragus, and these two crests are entirely disconnected. A third important point for comparison is the auricular lobe, which exists in man as a loose fleshy convex portion, pendant and free from cartilage. In a few apes the under border of the auricle is convex, but contains for the most part the broad cartilaginous continuation of the helix; only a small space beneath the incisura intratragica being free from cartilage. This is the first indication of the lobe, which exists only in man and the anthropoid apes.

Variations from the normal, as regards the dimensions, the form, or the inclination of the auricle, are sometimes observed.

Variations as to the dimensions of the auricle are to be considered from the individual standpoint as well as from a racial standpoint, and it is necessary to distinguish between the harmonious proportion which the width of the auricle bears to its length—*i.e.*, between long ears and broad ears—as well as between large ears and small ears. The proportion which the height of the auricle bears to its width is the physiognomical auricular index, while the proportion between the true length of the auricle and the true width of the auricle is the morphological auricular index. The first may be expressed mathematically by the formula $\frac{\text{width} \times 100}{\text{height}}$ and the second by the formula $\frac{\text{base} \times 100}{\text{length}}$. The first is a true index for comparison between the auricles of different individuals and races, but is of no use, as was shown above, when the auricle of man is compared with that of animals. It is then necessary to employ the second formula.

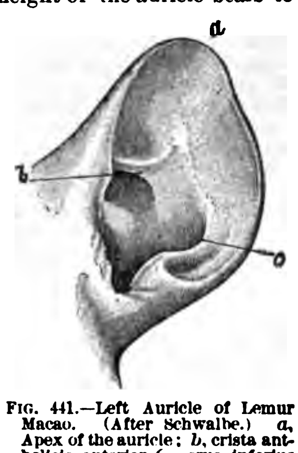


FIG. 441.—Left Auricle of Lemur Macao. (After Schwalbe.) *a*, Apex of the auricle; *b*, crista anthelicis anterior (= crus inferius anthelicis); *c*, crista anthelicis inferior.

Among races the Mongolians have the smallest auricles, those of Europeans are larger, and the negroes have the largest auricles. As we descend to the anthropoid apes, the gorilla, the chimpanzee, and the orangoutang, and so

on to the lower types of mammalia, we find the auricles continue to grow in size, that is, according to the physiognomical index; but when we measure these same auricles according to the morphological index, the reverse is found to be true, *i.e.*, that man has the widest auricles in relation to their length.

Variations in the Form of the Helix.—These are the following: the failure of its posterior or even of its superior

FIG. 442.—Tubercle of Darwin, Looking Forward and Downward, upon a Normally Involuted Helix—the Most Common Type.

FIG. 443.—Tubercle of Darwin, Looking Backward and Upward upon a Helix Which is Imperfectly Involuted—Pointed Auricle.

FIGS. 442 AND 443.—1, Tubercle of Darwin; 2, posterior border of helix, normally involuted in Fig. 442, not involuted in Fig. 443; 3, tragus; 4, concha; 5, lobule. (After Testut.)

border to become inverted; the joining of the root of the helix with the antihelix; the division of the root of the helix into two or more branches.

Variations in the Antihelix.—Complete absence or greatly diminished size; an absence of its superior crus, or a doubling back of this crus and the consequent formation of an extra fossa.

Variations in the Tragus and Antitragus.—Attenuation or absence; division of antitragus into two tubercles.

Variations in the Lobe.—Very small size; adherence of its edge to the integument of the face; exaggerated vertical development; division into two parts, viz., an anterior and a posterior segment.

Tubercle of Darwin.—Of the many morphological anomalies, one of the most interesting is a projection, more or less marked, which appears on the free edge of the helix at the junction of its superior with its posterior border. It is sometimes found in the form of a simple tubercle or of a triangular plate. In the great majority of cases in which the helix is normally involuted, the Darwinian tip points downward and backward (Fig. 442); but when the posterior border of the helix is not involuted in consequence of arrested development it points upward and backward (Fig. 443), and the auricle terminates in a point as in those of animals. This last position indicates exactly its anatomical significance, but however it be placed on a helix that is involuted or upon one that is not, it is always homologous with the ear tip of animals. It is always to be found in the human embryo before the sixth month, at which time the helix begins to roll in.

Variations in the Inclination of the Auricles.—These may be, as noted above, an abnormal slanting auricle or an auricle in which the cephalo-auricular angle is over 50 degrees. All these variations from the normal are of interest to alienists and criminologists as they are to be found to a greater extent among the degenerate than among normally developed persons.

Physiological Function of the Auricle.—Darwin, Küpper, and others look upon the auricle as an appendage which has become useless in man. On the other hand, there are those who, like Gruber, believe that the auricle acts as a reflector and a conductor of sound waves toward the auditory canal. Weber believes it to be of service in locating the source of sound. Burnett considers that the auricle is a resonator; the region of the helix and its fossa resound to the deeper partial tones, the antihelix and its fossa to the intermediate partial tones, and the concha to the higher partial tones, and these tones are so blended by the auricle as to be received by the auditory nerve as a whole tone.

Robert Lewis, Jr.

The information furnished in the present article has been drawn largely from the following sources:—
L. Testut: Traité d'Anatomie Humaine. Paris, 1897. Third edition.
Karl von Bardeleben: Handbuch der Anatomie des Menschen, Jena, 1897. Das Aeussere Ohr, von G. Schwalbe.

AURORA SPRINGS.—Miller County, Missouri.

POST-OFFICE.—Aurora Springs.

ACCESS.—Viâ Jefferson City, Lebanon and Southwestern Railroad—a branch of the Missouri Pacific system—35 miles southeast from Jefferson City. Hotels.

This resort is located on a spur of the Ozark Mountains, at an elevation of about 1,000 feet above the sea level. The climatic conditions here are of a most salubrious and attractive character and the scenic beauties are unsurpassed. It was a visit to this locality which led Bayard Taylor to remark: "I have travelled all over the world to find in the heart of Missouri the most magnificent scenery the human eye ever beheld." The country may be described as a succession of narrow ravines, and well-wooded, high, dividing ridges, running in a general east and west direction, with picturesque streams of clear water winding through and cutting the ridges at right angles, forming narrow gorges, which have, coursing down their sides, sparkling rivulets and saucy brooks, fed by springs situated on the hillsides. The springs are located under a magnesium limestone formation at the entrance to a charming park and near the headwaters of Saline Creek. The surrounding country slopes gradually to the southeast, and is protected from the winter winds by the higher ground to the north, while the cooler breezes of the summer come from the south and west—down the Osage valley. There are numerous springs in the neighborhood, the principal ones being known as the "Round," the "Bluff," the "Healing," and the "Bath" spring. A sulphur spring is located about seven miles farther down Saline Creek. The Round spring has been analyzed by Prof. Clifford B. Richardson, analytical chemist, Department of Agriculture, Washington, D. C., with the following result:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium sulphate	2.42
Magnesium chloride	6.95
Sodium chloride	4.01
Ferrous carbonate	5.13
Ferrous oxide	0.93
Lithia	1.43
Total	20.87

This water is almost a pure chalybeate. It has a sharp tonic effect on the physical economy, bracing up the digestion, promoting the appetite, and inducing healthful sleep and rest. Its best effects have been observed in cases of dyspepsia, rheumatism, scrofulous complaints, and renal diseases, and in the debility resulting from nervous affections and uterine complaints. Visitors will find excellent hotel accommodations and all facilities for hot, cold, and steam baths.

James K. Crook.

AUSCULTATION. See *Chest Diseases, Physical Diagnosis of.*

AUSTRALIA.—No exhaustive description of the climate of this great continental island, extending from 10° to 40° south latitude, will be attempted here, even if the data were at hand for so doing. The articles upon *Melbourne*, *New South Wales*, and *Victoria* in the following volumes of this HANDBOOK discuss the climatic conditions of those regions. In the present brief notice only those portions of Australia which are of interest to health seek-

ers, and especially to those suffering from pulmonary tuberculosis, will be considered.

In the first place, it must be remembered that the voyage to Australia possesses considerable value as a health measure; less so now, it is true, than in the days when one had to depend entirely upon sailing vessels. Furthermore, since the high-altitude treatment of consumption has come into favor, the benefits of a sea voyage for this class of patients have been somewhat lost sight of. In those earlier days the voyage to Australia or to New Zealand, around the Cape of Good Hope, was generally selected on account of its length. According to Weber ("Climate and Sea Voyages in the Treatment of Tuberculosis," Boston *Medical and Surgical Journal*, June 8, 1899), the following characteristics are to be attributed to sea voyages: (1) Purity of air; (2) slight range of temperature; (3) abundance of light; (4) constant movement of the air; (5) mental rest.

As this author, however, wisely remarks: "If one examines the conditions of an ocean voyage more exactly, he finds that these advantages are not always completely presented." The purity of the air is wanting in the sleeping cabins and saloons; the heat of the tropics is oppressive; the treatment of a serious illness on a sea voyage is difficult; and there are the storms and calms. "From what I have observed," concludes Dr. Weber, "I would give it as my opinion that sea voyages can do good service in a certain number of tuberculous cases, but that in most such cases other climatic and hygienic methods of treatment exercise at least just as good an influence." "If, however," continues Weber, "persons of strong constitution, who like sea voyages, develop phthisis under the influence of overwork or mental worry, long sea voyages are to be preferred to all other methods of treatment." This statement, as it appears to the writer, can scarcely be accepted without further qualification. (For a further consideration of this subject the reader is referred to "Ocean Voyages in Phthisis," by Dr. Parkes Weber, in *The Practitioner*, June, 1898; and to "Aero-Therapeutics" by C. Theodore Williams, 1894.)

The climate of those portions of Australia which one is likely to visit presents the following general characteristics: In summer the heat is apt to be at times excessive, frequently exceeding 100° F. at Melbourne, Sydney, and Adelaide; but the air is so dry that one is not rendered particularly uncomfortable by it, nor is it enervating. The hot wind which, "arising in the great central Australian desert, sweeps across the pastoral plains, rises over the range of mountains, and descends with fury upon the coast," may raise the temperature to 110° F. These hot winds are often followed by cold blasts from the Antarctic Circle—blasts which lower the temperature thirty or forty degrees in as many minutes. That such hot winds are not very frequent may be judged from the fact that Melbourne, for instance, has only fourteen hot wind days annually. There is the usual amount of dust, that inseparable accompaniment of a hot and dry climate. "In no country in the world," says Lindsay, "is the sky so seldom overcast, or the interruptions to the pursuit of business or pleasure so few." The winters are mild; "snow and frost are rare upon the lowlands and coast of Australia, and in many places are quite unknown." Lindsay enumerates three climatic regions: (1) the Littoral; (2) the Highland, and (3) the region of the Inland Plains.

The *Littoral*, where the principal cities are located, consists of a narrow strip of country, from 30 to 150 miles in breadth, which lies between the ocean and the mountains. Owing to the variability of the climate, the winds above mentioned, the heat, and the dust, this region—with the exception, perhaps, of a few sheltered spots—is not to be recommended to invalids.

The *Highland region*, embracing the mountain range of the Australian Alps and the Blue Mountains, which vary in height from 3,000 to 7,000 feet, extends from Queensland to South Australia. Many varieties of climate are represented in this region, but as yet there are but two or three resorts where proper accommodations can be obtained. These are: Mount Macedon, in Victoria, where is an excellent sanitarium; Bræmar Woodend, situated upon a plateau at an elevation of 2,500 feet, and connected with Melbourne by rail, 44 miles distant; and Catoomba and Mount Victoria, in New South Wales. The latter, at an elevation of 3,490 feet, is 77 miles from Sydney, and has a mean annual temperature of 53° F.

The *region of the Inland Plains*, whose climate is characterized by heat, dryness, and sunshine, is divided into two districts: the Riverina in New South Wales, and the Darling Downs. The Riverina is the centre of the sheep-farming industry. It is bounded on the west by the Central Desert, on the south by the Murray River, on the north by Queensland, and on the east by the Darling Downs, the second district of this region. In the Riverina the summer heat is severe, the thermometer occasionally rising to 110° F., but, on account of the extreme dryness, it is not much felt. "Hot winds and dust storms are frequent, but days of still, cloudless sunshine form the rule in summer." "In winter there is a little morning frost, but the midday is always warm. Autumn and spring present an almost ideal perfection of climate." Accommodations are afforded in the towns, especially at Deniliguin, and "almost every squatter's house has, or has had, its invalid visitant," where the young man with incipient phthisis works out his cure by adopting a pastoral life. There is railroad connection with Sydney and Melbourne from this district.

The Darling Downs have an altitude of 2,000 feet, and are somewhat cooler and less exposed to the hot winds; otherwise the climatic characteristics are similar to those of the Riverina. Accommodations can be obtained at the towns of Toowomba and Warwick; the former is 102 miles west of Brisbane. Droughts are not infrequent in these inland plains, and Hann mentions the report of a reliable person that at a station in Darling it had not rained for thirty months. At times much suffering is caused by the drought.

"Unquestionably the inland climate of Australia is highly beneficial for early phthisis," says Williams, "and can be strongly recommended to more or less vigorous patients with pastoral tastes, who are prepared to spend years in the recovery of their health." It is well to bear in mind, if one contemplates a trip to Australia, that our winter is their summer, and it is strongly recommended that the invalid should plan to arrive there in the winter or early spring rather than in summer.

For the geological formation, vegetation, and scenery of Australia the reader is referred to the general description of the country in books of travel, etc. For the information given above the writer is chiefly indebted to Lindsay's "Climatic Treatment of Consumption," London, 1887, and Williams' "Aero-Therapeutics," London, 1894. *Edward O. Otis.*

AUTO-INTOXICATION.—To the writings of Bouchard and his pupils is due much of the wide interest which during the past decade has been aroused in the subject of auto-intoxication. Bouchard's views, indeed, have not all received acceptance from later investigators, and in many phases the subject is still only an attractive and plausible hypothesis; but with each year new facts are evolved, especially from the domains of physiological and pathological chemistry, which in one place or another furnish the needed link to the gradually forming chain of evidence.

Albu defines auto-intoxication as a poisoning of the organism by the products of its own metabolism, which products may be either normal in character but excessive in amount, or abnormal in character. Among the abnormal products are to be distinguished those which under normal conditions would promptly undergo further change, and those which in the healthy organism are never found or are present only in minute quantities.

The human body is, to quote Bouchard, both a receptacle and a laboratory of poisons. They are contained in the

food, they are formed in large quantity during the process of normal digestion, and they exist in the fluids and tissues of the body; and yet the healthy individual is not poisoned.

While certain organs are occupied in manufacturing poisons, certain others are busily engaged in arresting these poisons and excreting them, or in converting them into useful or harmless bodies. Upon these "organs of defence," then, rests the responsibility of so disposing of the constantly forming poisons of the body that the latter is protected from their deleterious effects. And this these defensive organs are capable of doing when all the bodily functions are acting normally and when no excess of noxious matter is introduced from without. The adjustment, however, is so delicate that a functional derangement of any one of the organs may suffice to permit of the accumulation in the blood of enough toxic material to give rise to systemic disturbances of an acute or chronic nature—in other words, to auto-intoxication.

These organs of defence are of two kinds: 1. Organs of transformation or arrest, *i.e.*, liver, gastro-intestinal mucous membrane, spleen, lymph nodes, adrenal bodies, thyroid gland, etc. These organs possess the power of checking different poisonous bodies brought to them by the blood or lymph, and of converting them into non-toxic and assimilable substances, or of filtering out and rejecting them entirely, as is the case with the liver and its excretory product the bile. 2. Organs of elimination, such as kidneys, lungs, skin, and intestines, whose duty it is to remove from the circulating fluids such toxic substances as either escape the organs of arrest or are formed later in the other tissues, *e.g.*, the muscles.

Such, in brief, are the essential points of the present theory of auto-intoxication, and certainly they supply at least a most tempting hypothesis for the explanation of a vast number of otherwise inexplicable conditions. It remains to see what proofs can be offered in support of the theory.

It is at once evident from the complex and unstable character of many of the poisons that to obtain such direct proof as the isolation of the toxic matters from the blood or tissues, and the induction of symptoms of poisoning by their injection into animals, must be in many cases a task beset with great difficulties or even impossible of accomplishment.

It happens, therefore, that for many of the individual intoxications only indirect proofs or inferences have been supplied. These have been furnished in many ways: by the study of the physiology of the glandular organs; of the toxicity of the excretions, and in particular of the urine; of the anatomical changes and clinical pictures as compared with those produced by known poisons; of the etiology, and of the results of treatment.

In studying the character of the different poisons of the body a distinction should be made between those resulting from intra-cellular changes within the organism and those which arise from the action of saprophytic bacteria inhabiting the stomach and intestines.

Among the former are to be classed the leucomaïns, "those basic substances which result from tissue metabolism" (Vaughan).

Since the hydrocyanic acid radical is a frequent constituent of leucomaïns, it is not surprising that some of these are known to be intensely poisonous.

The name "ptomaïn" was given by Selmi to certain organic compounds, basic in character, which are formed by the action of bacteria upon nitrogenous matter. These all contain nitrogen as an essential part of their basic character and have been called putrefactive alkaloids. Not all ptomaïns are poisonous; indeed, many of them seem to be quite inert. Brieger restricts the term ptomaïn to the non-poisonous basic products, and to the poisonous ones gives the name of "toxin." The name "toxalbumin" he has reserved for certain powerful non-basic poisons whose chemical nature is still in doubt.

These obscure nitrogenous bodies, however, comprise only a very small part of the sum of the chemical substances found in the gastro-intestinal canal and in the interior of the body which may, under the proper conditions and when in sufficient quantity, prove toxic to the organism. Many of these bodies will be referred to later in discussing the individual intoxications.

Classification.—A comprehensive and satisfactory classification of the different auto-intoxications in the present state of our knowledge of the subject is hardly to be expected. Perhaps the most satisfactory is that of Albu, which is here given:

1. *Auto-Intoxication Caused by Failure of Function of Definite Organs.*—These are gland affections with or without anatomical changes. Of the former class that of simple atrophy seems to be much the most frequent condition. To this category belong myxœdema and cachexia strumipriva, pancreatic diabetes, acute yellow atrophy of the liver, and perhaps also Addison's disease. These are all diseases which owe their existence to the failure of function of those organs to which modern physiology ascribes the destruction of the toxic products of metabolism which are constantly formed in the organism.

2. *Auto-Intoxication by General Anomalies of Metabolism without Evident Localization.*—These are diseases in which the intermediate products of metabolism and the products of retrograde metamorphosis reach the general circulation. To this class belong diabetes in general, oxaluria, gout, etc.

3. *Auto-Intoxication through Retention of the Physiological Products of Metabolic Action in the Different Organs.*—In this group are included the severe manifestations after extensive burns of the skin, the CO_2 poisoning in conditions of dyspnœa, uræmia, etc.

4. *Auto-Intoxication through Excessive Production of Physiological and Pathological Products of the Organism*, *e.g.*, Hydrothionæmia, acetonuria, diaceturia, cystinuria, diabetic coma, coma carcinomatosum, etc.

Between the third and fourth groups, and perhaps belonging to both, stand most of the auto-intoxications which arise from the gastro-intestinal tract and which follow the most various acute and chronic digestive derangements: Gastric and intestinal vertigo; asthma dyspepticum; those irritative and paralytic manifestations of the central nervous system which develop in the course of chronic constipation; dilatation of the stomach, strangulated hernia, etc.; various skin affections and many functional diseases such as tetany, Thomsen's disease, infantile eclampsia, etc.

In addition to the list of diseases already mentioned it seems quite possible that later developments may show that to the auto-intoxications must be added also many anomalies of nutrition and blood dyscrasias such as chlorosis, pernicious anæmia, leucæmia, the cachexia of cancer, and perhaps, too, scorbutus, purpura, hæmophilia, etc.

Auto-Intoxications of the Gastro-Intestinal Tract.—The auto-intoxications which apparently have their origin in the gastro-intestinal canal are not only the most frequent, but include also some of the most important and typical examples.

It is by no means easy, in attempting to differentia[illegible] between auto-intoxications and those intoxications not [illegible] autogenous nature, to say in every case just where t[illegible] line shall be drawn.

Those intoxications which develop as a result of failu[illegible] of function of the organs of defence, and when no to[illegible] matters have been introduced from without, are clea[illegible] auto-intoxications. On the other hand, poisoning resu[illegible] ing from the ingestion of noxious matters generated tainted meat, ice cream, etc., or that resulting from t[illegible] accumulation in the body of toxins formed by bacte[illegible] not normally found there, *e.g.*, the diphtheria or tetan[illegible] bacillus, are manifestly not auto-intoxications.

It is possible that certain diseases may be the result [illegible] intoxications which are of both autogenous and exog[illegible] ous character. Bouchard so regards typhoid fever. [illegible] addition to the infection of the body by the pathoge[illegible] bacterium and its toxins, he believes that the intesti[illegible] ulcerations may be the cause of an auto-intoxication eit[illegible]

Auto-Intoxication.

by increasing normal fermentation or by inducing abnormal fermentative processes.

The Poisons of the Gastro-Intestinal Canal.—Most of the auto-intoxications of the gastro-intestinal tract are caused not by the generation of foreign poisonous substances, but by the development in execessive quantities of those toxic bodies which, in small amount, are a part of the normal digestive processes. Among the abnormal toxic substances occasionally formed are to be mentioned chiefly β-oxybutyric acid, tetra- and penta-methylendiamin, and the so-called alcaptan.

There are chiefly two processes which lead to the production, in the gastro-intestinal canal, of injurious substances in large quantities—fermentation and putrefaction.

These are both processes without which the normal course of digestion could hardly be conceived and which do not cease even in prolonged hunger. Fermentation has its seat chiefly in the stomach and involves chiefly the carbohydrates. Putrefaction, on the other hand, is almost altogether an intestinal process and affects especially the albuminoids.

These catabolic processes are produced by micro-organisms which are introduced with the food or are swallowed with the saliva. Miller has found a lactic-acid-forming bacillus in the saliva of the mouth. Unfortunately, up to the present time only a few of the bacteria of the several processes of fermentation and putrefaction are known.

The carbohydrates may undergo any one of four different forms of fermentation—the lactic acid, the butyric acid, the acetic acid, and the yeast fermentation,—each of which is produced by its specific bacterium. The acids are in part further transformed into certain gases, especially hydrogen and carbon dioxide.

The products of the putrefaction of albuminoids differ greatly from those of the fermentation of the carbohydrates. They may be divided into several groups:

1. NH_3, N, CO_2, H_2S, methylmercaptan and cystin.
2. Substances from the amido-acid series, of which leucin is a type.
3. Substances from the group of aromatic bodies which are the derivatives of benzol, *e.g.*, phenol, cresol, indol, skatol, tyrosin, and alcaptan.

Aceton is still another product of the putrefaction of proteids which has been found in both gastric and intestinal contents.

Hydrogen sulphide is believed not to be a product of normal putrefaction in the intestine. It is found, however, under many pathological conditions not only in the intestines, but also in the stomach. When in large quantities it may reach the blood and produce typical H_2S poisoning such as occurs in certain occupations. This H_2S poisoning, which occurs in certain acute gastro-intestinal disturbances, is termed hydrothionæmia and is a good example of a pure gastro-intestinal auto-intoxication. All these above-mentioned substances, except perhaps H_2S, are, in greater or less quantity, products of normal digestive chemistry.

There are still to be mentioned those foreign poisonous bodies which are formed from the albuminoids in certain abnormal putrefactive processes. To these belong the ptomaïns, toxins, toxalbumins, etc. Neither their mode of formation nor their grouping is well understood. It is possible that they may be formed in minute quantities during normal digestion.

Doubtless the stagnation and decomposition of the gastro-intestinal contents favor their development; so they exist by preference in the contents of dilated stomachs and in the retained fæces of intestinal obstruction, constipation, etc.

Three varieties can be recognized:

1. Alkaloid-like bodies of the constitution of the pyridins or the chinolins, such as Bouchard found in normal fæces.
2. Diamins; in particular tetra-methlyendiamin (putrescin) and penta-methylendiamin (cadaverin), which are found in cystinuria, severe diarrhœas, etc.
3. Toxalbumins; unknown poisonous, nitrogenous bodies.

Auto-Intoxications of Gastric Origin.—The results of absorption of the normal products of gastric digestion in excessive amount, or of the toxic products of abnormal digestive processes, may manifest themselves in symptoms of the most varying kind and degree of severity. Brunton suggests that the lassitude and drowsiness which are so apt to follow a full meal may depend upon the absorption of an excess of the normal digestive products, and so be a mild manifestation of auto-intoxication.

Most of the severe constitutional disturbances associated with gastric disorders in childhood are believed by Heubner to be due to auto-intoxication. Of the chronic intoxications of gastric origin those associated with dilatation of the stomach deserve especial mention. In this condition there exists every favorable condition for the formation of fermentative and putrefactive products and for their absorption. These intoxications accompanying gastric dilatation are especially characterized by the periodicity of the appearance of the symptoms.

Among other chronic auto-intoxications should be mentioned migraine, certain other periodic headaches and neuralgias, and possibly, too, the gastric crises of tabes dorsalis.

Positive evidence that migraine should be classed with the auto-intoxications is still quite lacking, but there can be no question that in some cases at least there exists a very close relation between the periodic manifestations and gastric derangements.

Tetany.—This disease, says Albu, furnishes the most brilliant example of a gastro-intestinal auto-intoxication. Most of the cases are now known to be associated with some form of gastro-intestinal disturbance, *e.g.*, acute and chronic gastritis, dyspepsia, hypersecretion, dilatation of the stomach, intestinal worms, etc. Of these, dilatation of the stomach is the condition most frequently found. Of the three theories offered to explain the close relation of tetany to stomach diseases, that of auto-intoxication has now been very generally accepted. Various toxic substances have been isolated from the dilated stomachs of such cases, but none has yet been proven to be the cause. A study of the urine, however, has given better results. Albu obtained from the urine in one case a metallic salt of an alkaloid-like body which was constantly present during the tetany attacks and never during the free periods.

Many of the clinical phenomena are best explained upon the theory of auto-intoxication. Finally, in animals an artificial tetany can be produced by the injection of chloroform and ergotin.

Copræmia.—It has long been recognized that chronic constipation is apt to be associated with such symptoms as dizziness, headache, lassitude, insomnia, hypochondriasis, and even migraine, neuralgia, etc. To explain these effects two theories have been offered: 1. That of reflex action due to the irritant effects of the hardened fecal masses upon the nerves of the intestine; and 2. That of the absorption, from the intestine, of the putrefactive products of the retained fæces Of these, the latter seems in every respect the more plausible, and has received indirect substantiation in the discovery that in obstinate constipation there is almost always an increased transfer of the products of putrefaction from intestines to urine. The nature of the absorbed products is unknown. It seems probable that they are for the most part bodies belonging to the group of aromatic substances such as phenol, indol, skatol, etc. For this speaks the fact that in constipation there is frequently an increase in the excretion, by the urine, of indican and also of the ethereal sulphates. Bouchard is inclined to believe that the poisons of the fæces are alkaloidal bodies belonging to the ptomaïn group. His view that many of the constitutional symptoms in intestinal obstruction and allied conditions were due to the absorption of poisons from the retained fluid fæces, has received support from the apparently toxic nature of the nephritis which not infrequently develops in the course of these affections. Bou-

chard found the urine in diarrhœal conditions much more toxic than when the fæces were normal.

Eclampsia Infantum.—That a close relation exists between many of the convulsions of childhood and gastro-intestinal disturbances cannot be denied. These disturbances, to be sure, may be of the most varied nature and in some of the cases seem to depend upon the presence of intestinal parasites. In the explanation of these convulsions is seen again the struggle for precedence between the reflex and the auto-intoxication theories, and again the latter seems more satisfactorily to answer the requirements. Even in those cases depending upon the presence of intestinal worms the symptoms are attributed by several of the most recent writers to the absorption of the toxic products formed by the living or dead parasites.

Much attention has recently been given to the association of acetonuria with many cases of eclampsia infantum. Aceton is without doubt frequently found in the urine in these cases, and von Jaksch claims for it a convulsive effect, and goes so far as to describe a particular clinical picture which he terms epilepsia acetonica. Baginsky also has found aceton in the urine of many cases of infantile convulsions, but he has never found it in the vomitus or fæces. Moreover, acetonuria is frequently seen in febrile conditions not associated with convulsions, and he regards the presence of aceton in the urine as a symptom rather than as a cause of infantile eclampsia.

Nervous and Mental Diseases.—As might be expected, a great number of functional nervous diseases have been attributed with greater or less plausibility to auto-intoxication.

In the case of tetany, uræmia, eclampsia, and eclampsia infantum there are substantial grounds for such belief. In many cases, however, there is, up to the present time, little that can be offered in support of this theory.

The relation of *epilepsy* to auto-intoxication is by no means settled. Griffith has isolated in large quantities from the urine of epileptics an alkaloidal body to which he ascribes causal attributes, but his findings have hitherto not been verified.

There remain to be mentioned three very rare nervous affections which may with considerable probability be attributed to auto-intoxication.

1. A periodic paralysis of the extremities, first described by Hartwig, in which there is the periodical appearance of extensive paralysis associated with sudden loss of electrical irritability. These symptoms last for hours or days and then disappear. The affection has been seen to develop after attacks of malaria, after infectious diseases, and even after the ingestion of certain foods.

2. *Myasthenia Gravis Pseudo-Paralytica* (Jolly).—This recently described condition consists essentially in the periodic development of extreme muscular weakness of the whole body. It resembles clinically the results of the action of proto-veratrin upon the muscle and nerve endings and those of extreme muscular fatigue.

3. *Myotonia Congenita, or Thomsen's Disease.*

There is ground for believing that certain psychoses, especially those of a more acute nature, may be the manifestations of an auto-intoxication. Several investigators have found an increased toxicity in urine from cases of melancholia and from other psychoses. It is still too early, however, to formulate definite views upon the subject.

Gastric and Intestinal Vertigo. Asthma Dyspepticum.—A close relationship has for a long time been recognized between gastro-intestinal derangements and certain forms of vertigo and asthma; and while proofs are still lacking, there are many reasons for believing that these conditions may sometimes depend upon the absorption from the gastro-intestinal canal of certain toxic substances.

Skin Diseases.—From the importance of the skin as an organ of excretion it may be fairly assumed that the disturbances of the skin in many diseases are to be taken as evidence of an attempt on the part of the skin to excrete certain poisons, *e.g.*, in uræmia, diabetes, the exanthemata, etc.

Such disturbances may manifest themselves in the form of almost any known eruption, the erythematous and urticarial types, however, being those most frequently seen. These skin affections seem especially frequent with gastro-intestinal auto-intoxications. Singer has found almost regularly in the skin diseases associated with digestive disturbances, an augmentation of the putrefactive products as shown by the increased amount of ethereal sulphates in the urine.

Diseases of Muscles.—In 1889 Wagner described under the name of *polymyositis acuta* an inflammatory disease of the muscles throughout the body, associated with gastric and constitutional symptoms, for which Senator has suggested, with some plausibility, an origin in auto-intoxication. There is as yet, however, no proof of this.

Coma Carcinomatosum.—In cancerous conditions of the gastro-intestinal tract, and in various cachectic conditions due to such unlike diseases as the severe anæmias, chronic nephritis, miliary tuberculosis, and cirrhosis of the liver, there sometimes develops a peculiar form of coma which is closely allied to diabetic coma and which is known as carcinomatous or dyscrasic coma. This has a close clinical resemblance to the coma of diabetes, but differs somewhat in a few of its symptoms and especially in its prognosis. In the urine of these cases as well as of those of diabetic coma are found aceton, diacetic acid, and β-oxybutyric acid. These bodies seem to be products of the destructive metabolism of the albumins which is brought about by the action of toxins present in diabetes, cancer, and the other cachexias. It seems probable that both the coma and the acids found in the urine are the expressions of the action of these toxins, rather than that the coma is the result of the poisoning of the body by the acids themselves. The condition common to all these diseases is that of grave disturbance of nutrition, which means excessive albumin destruction. Klemperer found that the blood serum of a cancerous patient, when injected into a dog, caused a much greater increase in the albumin conversion than did the serum of a healthy person.

The nature of this coma-inducing poison is as yet quite unknown. It is interesting that the carcinomatous coma has thus far been observed only in cancers associated with the gastro-intestinal tract.

Chlorosis. Pernicious Anæmia. Leucæmia.—Among the various theories regarding the cause and origin of chlorosis, that one which ascribes it to a chronic intestinal auto-intoxication or copræmia has been warmly advocated by Sir Andrew Clark, Bouchard, Duclos, Nothnagel, Hüllmann, and, more recently, by Garrod and Forchheimer. The last-named investigator concludes that the origin of chlorosis lies in a disturbance of the hæmatopoëtic function of the intestinal mucous membrane. He believes this membrane to be the laboratory of hæmoglobin, since in rabbits he found the blood in the mesenteric vein to be much (eighteen per cent.) richer in hæmoglobin than that of the mesenteric artery, and in human blood that after each meal there was a considerable increase in the hæmoglobin content. Moreover, he obtained from the urine of chlorotic patients an alcoholic precipitate which proved poisonous to rabbits. This was evidently a nitrogenous substance, and was regarded by him as an intermediate body between albumin and peptone.

On the other hand, Rethers has failed to find in the urine of chlorotics that evidence of excessive intestinal putrefaction which is based upon an increase in the ethereal sulphates.

Although in many clinical aspects chlorosis corresponds closely to other known intoxications, and although there are many theoretical grounds for accepting such a view, there is still lacking sufficient evidence to justify the definite acceptance of the theory of auto-intoxication.

The same may be said concerning the primary pernicious anæmias and the leucæmias. A support for the auto-intoxication theory in these diseases is furnished by the fact that very marked changes from the normal metabolic processes are found in all forms of pernicious anæmia and leucæmia. A number of investigators have found in these a much-increased excretion of nitrogen,

and this albumin destruction does not occur in the simple anæmias. Anæmia of itself causes no increase of destructive metabolism, and when this occurs then some other agents must be at work. These agents can hardly be conceived as other than poisons acting through the blood upon the cell activity of the organism. Again, a marked diminution of blood alkalinity is found only in the severe forms of anæmia, and never in chlorosis and the simple anæmias.

Köttnitz regards leucæmia as a chronic peptonæmia and offers an ingenious theory based upon this to explain the great increase in leucocytes. His views have not yet been substantiated by others.

Hydrothionæmia.—This condition is of especial interest because it furnished the first positive demonstration of gastro-intestinal auto-intoxication. In 1864 Betz, a German, in two cases with peculiar and violent gastro-intestinal symptoms, demonstrated the presence of H_2S in both urine and fæces, and regarded it as an evidence of intestinal putrefaction.

The name hydrothionæmia is applied to the H_2S poisoning which develops in the course of an acute gastro-intestinal derangement, and is associated with symptoms similar to those of H_2S poisoning in certain occupations. The condition is a rare one.

Lately Boas and others have found H_2S in some quantity in dilated stomachs, but never in the urine.

It is doubtful if the nervous and psychical disturbances associated with chronic constipation are to be referred to the toxic effects of the H_2S which is sometimes present.

Acetonuria. Diceturia.—The interesting condition of acetonuria is discussed in detail elsewhere under its own title.

The presence of aceton in the urine has been demonstrated in a great number of different conditions which seem to have no relation to each other, and it has now become evident that acetonuria, in most cases at least, is rather to be regarded as a symptom than as a cause of disease. Even upon the origin of aceton there is not yet full accord. The weight of opinion, however, at this time, attributes its formation to abnormal metabolism of the albuminoids in the gastro-intestinal tract.

The presence of diacetic acid in the urine is usually of more serious import to the organism than is that of aceton, but here also there is much doubt as to whether it is to be regarded merely as evidence of abnormal metabolism or whether it itself is the source of an intoxication. It seems, in its origin, to be closely related to both aceton and β-oxybutyric acid.

Cystinuria. Diaminuria.—Cystinuria is a rare condition, the interest in which was greatly augmented by the discovery by Baumann and Udransky that in patients whose urine contained cystin there were also to be found in the urine bodies of definite chemical composition called diamins. From these could be separated two substances, penta- and tetra-methylendiamin, which were identical respectively with cadaverin and putrescin—bodies isolated by Brieger from putrid meat. These diamins, moreover, could be found as well in the fæces of these patients. Here, then, is an illustration of the actual excretion by the urine of toxic substances formed in the intestine. Since, as Brieger showed, the diamins develop only in certain definite putrefactive processes, it follows that in those suffering from cystinuria certain specific decomposition processes must occur to give rise to the diamins.

Diaminuria is found only in connection with cystinuria, but the cystin in these cases has not been found in the intestines. Whether or not the diamins have a toxic action upon the organism is not known. Cystinuric patients suffer from various symptoms, and it is possible that some of these may be dependent upon the formation and absorption of the diamins.

Oxaluria.—There is still some doubt concerning the origin of oxalic acid in the body, but it is probably an intermediate product of carbohydrate metabolism which, under normal conditions, is promptly further changed into CO_2 and water, but which under pathological conditions may be formed in excess or may not be properly transformed. Under these circumstances it will appear in the urine. Cantani believes oxalæmia to arise from excessive starch or sugar decomposition, and from this a distinct clinical picture to result which is characterized by emaciation, furuncles, abscesses, etc. He regards oxaluria as analogous to glycosuria and as having originated in the same way. There is, without doubt, some relation between diabetes and oxaluria, for not only are they frequently associated, but glycosuria and oxaluria have been known to alternate in the same individual.

The appearance of small quantities of the oxalates in urine does not indicate an anomaly of metabolism. When large amounts are present regularly, however, there must be some serious derangement of the processes of nutrition, and the oxaluria may perhaps then be the expression of a definite auto-intoxication.

The Poisons of the Urine.—Normal urine, which for a long time was believed to be not toxic, is now known to be distinctly poisonous, and this toxicity is ascribed in large part to the salts of potassium. These salts alone, however, do not make up the entire toxicity, since the urine itself is found to be more poisonous than the urine ash, and urine rendered free from potassium is still toxic. This unknown, organic "urotoxin" has been earnestly sought for. Bouchard gave to this search fresh impetus by the introduction of his method of measuring the toxicity of urine. This consisted in the intravenous injection of urine into animals and the determining of the amount necessary to produce death. The amount needed to kill 1 kgm. of animal was made the unit of toxicity or "urotoxy." In this way he could study and compare the different "urotoxic coefficients"—that is, the number of urotoxies which 1 kgm. of man can form in twenty-four hours. This coefficient in normal individuals averaged 0.464, and in pathological conditions varied between 0.1 and 2.0.

Bouchard found in urine at least seven distinct poisons, including a narcotic, a sialogenous, a convulsive, and a myotic one. He found the urine toxicity to be independent of its concentration, and found that in pathological states the toxicity was usually but not always increased.

These methods of Bouchard, which have been very extensively employed in France, are far from being wholly satisfactory, and the reliability of his results and conclusions have been questioned, especially in Germany, where much more exact methods have been employed.

Recently much attention has been paid to the *organic* poisons of the urine, and a number of alkaloid-like bodies have been isolated whose source Bouchard believes to lie in the putrefactive products of the intestines. It seems probable that these toxins are to be regarded not as the products of specific diseases, but rather as the cleavage products of albumin which appear in the urine when for any reason there is an excess of nitrogen excretion. It seems doubtful if the organic disease poisons themselves often appear in the urine. Their composition is so complex and unstable and they take such an active part in metabolism that they are likely to be broken up before reaching the kidneys.

It must be admitted that up to the present time the poisons of the urine have furnished little positive proof in support of the theory of auto-intoxication.

The subject of uræmia will be dealt with under its own title.

Auto-Intoxications of Hepatic Origin.—In spite of the many advances that physiology has made in the elucidation of the many functions of the liver, not all these are yet clearly understood.

As to the derangements of the biliary function, we must distinguish sharply between a cessation of bile formation (acholia), and the obstruction and the retention in the liver of the already formed bile (hypercholia).

The effects of the latter condition upon the organism are well understood, and depend—

1. Upon the failure of action of the bile as a digestive secretion, and
2. Upon the reabsorption of the bile into the blood

through the lymph vessels of the liver. Contrary to the view of Bouchard, it is now generally believed that the bile pigments are comparatively harmless and that the bile salts are the more actively toxic agents.

The group of severe nervous symptoms seen in grave disease of the liver and known as cholæmia depend, in all probability, however, not upon a poisoning by bile salts from hypercholia, but rather upon the serious metabolic changes caused by cessation of the bile-forming function, and probably at the same time cessation of the other functions.

That part of the urea formation of the body which takes place in the liver (the so-called "Schroeder's portion") is formed from ammonium carbamide, which is a destructive product of the albumins and the amido acids. In severe disease of the liver this "Schroeder's portion" of urea is usually lacking, and the unused ammonium carbamide is in part changed to ammonium carbonate.

The introduction of ammonium carbamide into the blood of an animal produces symptoms very closely corresponding to those which follow total extirpation of the liver.

The liver seems to prevent the entrance into the systemic blood of these toxic substances which are intermediate steps between albumin and urea, *i.e.*, leucin, glycocoll, the amido acids, and especially ammonium carbamide.

Insufficiency of the liver function, then, always favors the development of auto-intoxications from the gastro-intestinal tract.

Acute Yellow Atrophy. Cholæmia.—The ultimate cause of acute yellow atrophy, except in cases of phosphorus poisoning, is still entirely unknown. Whatever it may be, there can be little doubt that the symptoms depend upon the failure of the liver to exercise its functions in converting or rejecting the many toxic products of digestion carried to it by the portal vein. We therefore have a typical example of auto-intoxication occasioned by the failure of function in a particular, and in this case a most vital, organ of defence. As a result of the failure of liver functions, the blood is flooded with substances which normally are not found there. Among these, leucin and tyrosin are the best known. It is probably no single substance, but the sum of all the foreign substances circulating in the blood, which gives to the disease its clinical picture.

The appearance in the urine of leucin, tyrosin, and other foreign bodies, and the great diminution in the excretion of urea, are exactly what might be expected from cessation of liver activity. The irritation of the kidneys by these foreign bodies may well render their excretion less complete, and so complicate still further the situation. Moreover, since urea is an active diuretic, its great decrease may have the effect of still further impairing renal activity.

Diabetes.—Not the least important function of the liver is to arrest the sugar carried to it and to convert this into glycogen. The liver is not a perfect filter, however, and even under normal conditions a small quantity of sugar gets past the barriers and so reaches the blood. When sugar is formed in the intestine in amounts greater than normal, more of it is apt to escape the liver filter, and when this sugar in the blood reaches a certain amount it makes its appearance in the urine and thus is produced an "alimentary" glycosuria. Sugar in the blood possesses marked toxic properties, and seems especially to be a "protoplasm poison," leading in all severe forms of diabetes to vastly increased tissue destruction, to excessive albuminous metabolism, and to high nitrogen excretion. Whatever its cause, therefore, diabetes is still a typical example of an auto-intoxication.

Since destruction or extirpation of the pancreas is so regularly associated with severe diabetes, it is evident that the pancreas must have for one of its functions the regulation of normal metabolism much as has the thyroid gland.

With the failure of this sugar-controlling function of the pancreas the liver is quite unable to arrest all of the excess sugar carried to it, and the filter becomes altogether inadequate. The nature of this regulating function is entirely unknown. It may possibly depend upon a ferment.

Addison's Disease.—The modern theory, which regards Addison's disease as an auto-intoxication caused by failure of the specific function of the adrenals, while still lacking in direct proofs, has yet some interesting facts to support it and is gaining general acceptance. This view holds that the adrenals exercise some control upon the processes of metabolism whereby the action of certain toxic substances is neutralized or the bodies are converted into harmless ones. Just as the thyroid seems to have a regulating effect upon the mucin formation of the body and the pancreas upon sugar formation, so the adrenals have a specific influence upon the conversion of one of the most widely distributed nitrogenous, organic substances in the body, namely neurin.

AUTO-INTOXICATIONS OF THYROID ORIGIN.—The recognition of the relation between myxœdema and cretinism and the atrophy or destruction of the thyroid gland; the discovery that total extirpation of the thyroid was regularly followed by those cretinoid manifestations known as cachexia strumipriva, and the results of the treatment of myxœdematous conditions by thyroid extract, have served to throw much light upon the hitherto little understood functions of this ductless gland. It can now scarcely be doubted that the thyroid exerts some form of controlling action upon the products of digestion whereby complete assimilation is brought about. It completes the conversion of the absorbed foods and destroys certain unfinished toxic products of metabolism, in particular the mucin. The exact method of its action is not clear. It may be that by its cell activity the thyroid transforms into harmless bodies certain toxic ones brought to it by the blood, or that it generates a particular product which upon entering the circulation neutralizes the effects of certain poisons. It is possible that it may combine both of these functions. In any case, cretinism, myxœdema, and cachexia strumipriva must be regarded as auto-intoxications due to failure of function of a particular organ of defence.

In *exophthalmic goitre* we have a clinical picture which in many respects is the direct antithesis of that of myxœdema; furthermore, as Greenfield has suggested, the histological appearances are those of an organ in active evolution; finally, the poisonous symptoms produced by too large doses of thyroid extract bear a striking similarity to those of exophthalmic goitre.

These facts have naturally led many to the belief that Graves' disease is the result of a morbid activity of the thyroid gland; and although there are some contradictory facts still to be explained, this theory is the one now very generally accepted. Regarding the nature of the auto-intoxication, two views are held: one, that by some anomaly of function an abnormal and toxic secretion is formed; the other, that the symptoms depend upon the production of the normal secretion *in excessive amount.* The latter view seems at present to be the more plausible one.

It must be added that another hypothesis which has recently gained some adherents attributes the condition to an auto-intoxication of gastro-intestinal origin. One experimental fact seems to offer support to this view. Hürthle has found that by inducing jaundice through ligature of the gall duct in animals, a change in the activity of the thyroid was regularly produced whereby an excessive development of colloid resulted.

THE AUTO-INTOXICATIONS OF PREGNANCY.—The hypothesis which sees in many of the disorders of pregnancy the manifestations of a poisoning of the organism by the products of its own metabolic processes has much that is attractive and plausible in it, and in the case of certain affections, especially in that of eclampsia, can summon to its support a considerable number of very significant facts.

It has been clearly shown that during normal pregnancy an increased amount of work is put upon the

various organs of the body, and especially upon those concerned in the processes of metabolism and elimination.

The increased demand upon the organs can under perfectly normal conditions be met satisfactorily, and we see women go through their period of gestation with scarcely a single departure from the state of perfect health. These increased demands, however, are prone to bring to light any inherent weakness in an organ which in the non-pregnant state may perhaps be capable of performing its functions most satisfactorily.

Among the organs of defence which are likely in pregnancy to manifest evidences of insufficiency, the liver and kidneys stand alone in point of importance. The liver in particular seems especially liable to fail in the performance of some of its manifold functions.

In the symptoms which, with greater or less reason, have been ascribed to auto-intoxications, are included the obstinate vomiting, salivation, insomnia, peripheral neuritis, the psychoses of pregnancy, bronzing of the skin, pruritus, jaundice, eclampsia, and acute yellow atrophy. In connection with salivation it is interesting to recall that one of the poisons found by Bouchard in normal urine was a powerful sialogogue.

Eclampsia Gravidarum.—The urine of eclamptic patients has been found to be much less toxic than that of other pregnant women, while the blood serum, on the other hand, is distinctly more poisonous than that in normal pregnancy. There can be no doubt, therefore, that in the blood of eclamptic patients there is an accumulation of poisonous substances. These in all probability are not the end products of destructive metabolism, but rather the intermediate products which have gained the circulation because of failure on the part of some organ to convert them into useful, or at least harmless, bodies. In other words, eclampsia presents every evidence of being a severe auto-intoxication.

While certain cases of eclampsia may be identical in nature with uræmia, there is much evidence to show that in many, and perhaps in most cases, the two conditions are quite distinct.

Within the past few years many investigators have called attention to the association of severe hepatic lesions with the manifestations of eclampsia, and it cannot be doubted that some at least of the severe anomalies of metabolism found in this condition are due to derangement of the liver functions. In some cases the liver has shown post mortem the typical appearances of acute yellow atrophy; in others those of hemorrhagic hepatitis; in others still, many necrotic areas have been found. Schmorl reports a series of seventeen cases, in every one of which serious changes in the liver parenchyma were found post mortem. These consisted usually in necrotic areas of hemorrhagic or anæmic character. Macroscopically the livers presented somewhat the appearance of acute yellow atrophy.

Stumpf suggests that the liver disturbances are of secondary nature, and that the origin of the poison may lie in the fetal organism. Under the influence of this unknown poison there is, he believes, an interference with the formation of urea. As a result of this, abnormal products of metabolism reach the blood and furnish a source of irritation to the kidneys, which, in turn, become insufficient and fail properly to eliminate these noxious bodies. The resulting abnormal condition of the blood acts also as a poison to the liver cells, and the failure of function of these precipitates the eclamptic attack through action upon the central nervous system.

Lewis A. Conner.

In an article such as the present one it is impracticable to give specific references for all the many assertions made therein. While numerous sources of information have been utilized, most of the statements contained are based upon those found in the following publications:

Bouchard: Lectures on Auto-Intoxication in Disease. English edition, 1894. F. A. Davis Co., Philadelphia.
Albu: Ueber die Autointoxicationen des Intestinaltractus, 1895. Hirschwald, Berlin.
Vaughan and Novy: Ptomains and Leucomains. Third edition, 1896. Lea Bros. & Co., Philadelphia.
G. Bouffe de Saint-Blaise: Les auto-intoxications de la grossesse, 1899. Baillière et Fils, Paris.
Bickel: Die Pathogene der Cholæmie, 1900. Bergmann, Wiesbaden.

Of these, the work of Albu has proved especially valuable, and to it those readers who desire more detailed information are referred.

AUTOMATIC ACTIONS.—By the term automatic actions, as applied to living bodies, we mean those movements which go on without any outside stimulus, the causes being in the body itself. For the sake of understanding them more clearly it is necessary to divide them into certain classes, which, so far as the higher animals are concerned, are as follows:

1. The Automatic Actions of Vegetative Life.—Under this head we have: (*a*) those of the respiratory neuro-mechanism; (*b*) those of the cardiac neuro-mechanism; (*c*) those of the vaso-motor neuro-mechanism; (*d*) the rhythmical movements of the stomach, intestines, spleen, and bladder.

The automatic actions in these classes may be modified by voluntary or other extrinsic influences, but they are, nevertheless, essentially independent of them. Thus the respiratory movements may be modified by volitional impulses, but they in the main go on rhythmically and independently. The mechanism of this process of automatism is well illustrated in the cardiac movements. The pulsations of the heart depend upon the stimuli rhythmically sent out by the intrinsic ganglia. The cells which originate these stimuli receive no excitation themselves except that furnished by the aliment from the blood. This aliment is constantly building up these motor cells into a more and more unstable condition. When the instability reaches a certain limit, the cell decomposes or explodes with a discharge of its force, after which it immediately begins to build up into instability again; and so the process goes on. This explanation applies to all the rhythmical automatic movements of vegetative life. The movements are performed by unstriped muscles, or the muscles of internal relation.

2. The Automatic Actions of Voluntary Life.—A second and much more striking class of automatic activities includes those involving voluntary muscles and the mind. They appear in various forms and in varying complexity according to the part of the nervous system which they involve. They may be divided as follows:

(*a*) *The Motor Automatisms.*—The harmonious movements of the eyes, the muscular adjustments called forth in the use of the voice, and of the jaws, mouth, and throat in suckling, are illustrations of motor automatism. The movements of the body and limbs in standing, sitting, walking, and in the various acquired dexterities, such as those of dancers, players, jugglers, acrobats, and skilled artisans, all are done automatically. Being, in man, acquired by practice, they may be spoken of as secondary automatic actions. They have for their anatomical substratum certain arrangements of nerve fibres and cells in the cerebellum, basal ganglia, and spinal cord. The conscious mind, though taking no active share, first fathered them, and stands in ready connection with them. It starts or stops the machinery, just as by touching the pendulum we start or stop a clock that has been wound. Physiology teaches also that all voluntary acts tend by repetition to become automatic. For voluntary movements, by repetition, are more and more easily and quickly performed, until at last they no longer possess the elements, such as duration and intensity, necessary to arouse consciousness, and they are then done automatically.

(*b*) *Psychical Automatism.*—There is another class of automatic activities closely related with the foregoing. Here volition and normal consciousness have no share at all, and the whole psychical life, so far as it appears at all, is automatic. The mind becomes a real machine, working in certain established grooves, unmodified by any volition or by any external or internal stimulus except such as gives it the start; just as the boy trims the sails and fastens the rudder of his toy boat, then launches it to sail as its mechanism directs.

This psychical automatism is represented in lower ani-

mals by many of their instinctive acts. In following its instincts the animal obeys no conscious purpose, but is impelled by unfelt stimuli from within, these stimuli being furnished by the peculiar anatomical arrangements and nutritive needs of its nervous system, inherited from its ancestors. Instinct covers in the lower animals, however, both the acquired aptitudes and the psychical automatisms in man.

This psychical or cerebral automatism is perfectly illustrated in the conditions known as trance and somnambulism. Here consciousness, while not exactly abolished, is in an aberrant state (see *Consciousness, Disorders of*), the will is suspended, but thought and feeling continue, and the body responds in systematized and apparently intelligent acts.

There are two distinctions which in a medical study of psychical automatism must be made: First, unconscious cerebration is a different thing from the psychical automatism which we are describing. The term unconscious cerebration should be limited to that very large share of our mental life which runs on beneath consciousness. Few persons, in carrying on a train of thought, bring every link in the logical chain into consciousness. We pass with a step from the first term to the last, the intermediate process being subconscious. In the association of ideas, one mental picture is often followed by another apparently remote, the missing links not rising into conscious view. Unconscious cerebration, therefore, refers simply to the subconscious part of our ordinary thoughts and feelings, and is one of the modes in which the mind naturally acts. Second, cerebral automatism, as understood by some writers, such as Carpenter and Luys, is made to include cerebral reflex acts, *i.e.*, all the mental acts which arise involuntarily in response to a stimulus. Thus we are told that the ready response of emotion at a dramatic climax, the instant formation of judgment where certain simple and common conditions are present, are all examples of cerebral automatism. From this same point of view, the common sense of mankind is but the automatically formed judgment upon the various affairs of life, which rises alike in the great mass of men. There is propriety in this view, and lines of distinction must be somewhat arbitrarily drawn. Nevertheless, the acts referred to are much more typically reflex than automatic acts, as, for example, when a novel situation excites at once spontaneously a burst of laughter. And it is better to limit the term cerebral automatism to those conditions of the mind in which spontaneity is abolished for a time and the psychical mechanism acts entirely apart from any conscious stimulus.

Cerebral automatism, as thus limited, is pathological and has a medical importance. It is a condition that is brought about by a number of causes, and makes a somewhat different clinical picture accordingly. Cerebral automatic states may be classified as follows: The epileptic, the somnambulic, the hypnotic, the automatism of inebriety, of insanity, of narcotic intoxication, of syphilis, of injuries to the head, and of overwork or cerebral exhaustion.

Epileptic Cerebral Automatism.—The automatic mental state which occurs in epilepsy accompanies much more frequently *petit mal* than *haut mal*. It generally follows the attack, but sometimes precedes it, and still more rarely takes its place, in which latter case the terms psychical epilepsy (Hughlings Jackson), masked epilepsy (Esquirol), epilepsia larvata (Morel) have been applied. It is a transitory psychical disturbance, and only one of several forms which occur at this period (see *Epilepsy*). Cases of epileptic automatism are numerous. In the simpler forms, the patient simply proceeds to do some ordinary but inapposite act. Often he begins suddenly to undress, or tries to go upstairs, and will climb upon a chair, or table, or shelf. Very frequently he puts some object near at hand in his pocket. Much more complicated acts may be done. A patient of Le Grand du Saule's, after an attack, found that he had taken passage in a steamer for Bombay. Gowers tells of a carman who, after an attack, drove for an hour through the crowded streets without accident. Trousseau relates the case of an architect who, when seized with an attack, would run quickly from plank to plank without falling; and Gowers, again, had a young lady patient who, during the epileptic automatism, would play the most difficult music. In some cases the emotional faculties are more involved, and attacks of transitory mania, or furious impulse, occur.

Artificial Cerebral Automatism, Hypnotism, Trance.—In the condition known as hypnotism, trance, mesmerism, "electro-biology," the phenomena of cerebral automatism are very perfectly shown, and an understanding of it gives the key to all the cerebral automatic states. When the hypnotic condition is produced artificially in a man he is instructed first to fix his attention upon some particular object, such as a bit of glass, which is held slightly above the level of vision, so as to put the ocular muscles upon a certain strain. After a few minutes, in sensitive subjects, the nervous force seems to lose its equilibrium and to concentrate itself in one particular direction. Little force is left to supply the rest of the conscious functions of the brain, and the whole mental life of the subject is narrowed into one field. The mind is but a point. The equilibrium of nervous force being once overturned, it continues unstable, and can be turned in one direction or another, according to the suggestion of the manipulator. Thus the hypnotic thinks that he sees a beatific vision, and every capacity of his mental being is expended on the feelings that such a vision excites. Or he is told that he is a murderer, and must die, and he is overpowered with fear and remorse. Or his mind is directed to the idea that one side of his body is insensible; he then feels no pain on that side. In any case, his mental energies are all so absorbed by some single dominant feeling, that ordinary sensory impulses coming up to the brain impinge fruitlessly upon consciousness, and awaken no sensations. The hypnotic is to all intents and purposes anæsthetic, blind and deaf to everything except an expected suggestion from the operator, which is the only link that holds him at the time to the external world. Under the domination of some particular idea or feeling, his mind may automatically cause him to perform many complex and apparently intelligent acts. The concentration of nervous force upon some particular function, such as that of sight, hearing, or touch, exalts these senses, so that vision is clearer, hearing more acute, and the touch more sensitive (see *Hypnotism, Somnambulism*). Such is, in brief, the physiology of hypnotic automatism.

Although the hypnotic condition is usually produced artificially, certain persons of a highly sensitive, nervous temperament are subject to spontaneous attacks, just as other persons suffer from the similar condition of somnambulism. Indeed, spontaneous hypnotic attacks are a kind of day somnambulism. Individuals thus suffering are generally of a hysterical temperament, with deficient will power, and their hypnotic attacks may accompany, or be complicated with, attacks of catalepsy, ecstasy, or hysterical seizures of various kinds. There are persons who have a congenital tendency to fall spontaneously into hypnotic states. Such was the case with a patient of Le Grand du Saule's, who, whenever he got into a state of excitement or expectancy, would fall off into a hypnotic sleep. Some of the reported cases of morbid somnolence belong to this class (see *Sleep, Disorders of*). In other instances the tendency to spontaneous trance states is acquired, as in a case reported by Finkelnburg: a young woman, having been once mesmerized by a professional, ever after was subject to spontaneous attacks of trance.

The condition of trance, or one closely allied to it, is induced voluntarily by the so-called trance speakers. It may also be brought on by some periodically occurring affection, as was shown in a case related by Dr. B. F. Berkley (*Western Journal of Medicine and Surgery*, N. S., vi., p. 204). A married woman, aged thirty-nine, for years suffered from trigeminal neuralgia, which finally ended in a severe form of tic douloureux occurring every

two weeks. After each attack she fell into a state of "somniloquence" lasting for an hour or two. During this time she would preach on religious topics with some amount of eloquence. She was a modern illustration of the similar states into which the priests of the Delphic oracle went when uttering their prophecies.

Hypnotic states are generally brought to an end by the passes of the manipulator. If the patient is left alone the hypnotic state continues for some hours, passing finally into true sleep, from which he awakens spontaneously. In some persons who are subject or have been subjected to periodical attacks of hypnotism, the mind recalls in one attack what occurred in the previous one. After such a person comes out from an attack he has no recollection, as a rule, of what was done in it. There are considerable variations in the degree or intensity of the hypnotic state. In the slighter degrees it resembles considerably that of profound reverie or abstraction. There is a distinction, however, between the absorbed reverie of the student and the absorbed contemplation of the hypnotic. In the former case the mind is constructing and building under a certain kind of voluntary direction; in the latter the mind is going automatically over old ground.

Traumatic Cerebral Automatism.—Very rarely injuries of the head produce such a pathological change in the brain as to make the person injured the subject of periodical attacks of cerebral automatism. In these cases the mental condition is the same as if the patient walked in his sleep or had been artificially hypnotized.

One of the most typical cases of this kind is that related by Mesnet, of the French soldier who, after suffering from a severe injury of the head, used to pass into automatic states lasting for days. He would then unconsciously go through all the routine actions to which he had been accustomed, such as dressing, taking a walk, smoking, etc.

The Cerebral Automatism of Inebriety.—Dr. T. D. Crothers has related some remarkable cases in which the effect of the long-continued abuse of alcohol has been to induce periodic attacks of cerebral automatism. The patients fall into a state very much resembling that of hypnotism. In this condition they may go through the ordinary routine of life in so perfect a manner that no one would recognize the peculiar aberration of the mind. After a period of hours, or even of a day or more, normal consciousness returns and they remember nothing of what they have been doing. One of the most remarkable illustrations of this kind was that of a railway conductor who, after passing into the automatic state, would take charge of his car, run the train, collect tickets, make change, and do all the other duties of his position. Finally, after returning home and awaking, he could remember nothing of what he had done.

Briefer and less typical attacks of cerebral automatism occur undoubtedly in very many cases of chronic inebriety.

Syphilitic Cerebral Automatism.—Cerebral syphilis sometimes produces states of automatic mental action, though these are not of a very typical kind. The syphilitic poison causes a kind of somnolent or stuporous condition, in which the patient appears incapable of voluntary intelligent acts. When roused and set upon ordinary tasks or routine duties, he goes through them automatically and almost unconsciously.

The Automatism of Brain Exhaustion and Brain Disease.—Luys ("The Functions of the Brain," p. 183) relates the history of a young man who had been for several days engaged in making calculations of compound interest, which had caused a great tension of his mind. One evening, after dinner, he was about to go to sleep when, as he says: "Without the slightest encouragement on my part, in a state between sleeping and waking, I began, without the smallest volition on my part, to calculate and go over again exactly the same problems as when in my office. The cerebral machine had been set in motion too violently to be stopped, and this involuntary work went on in spite of me, and in spite of all the means I endeavored to employ to cause its cessation, that is to say, for from about three-quarters of an hour to an hour and a quarter." Many persons, after an evening of exhausting study, on retiring to bed have experiences somewhat similar to the above. Healthy persons also discover a little of this cerebral inertia in their disinclination, or even absolute inability, voluntarily to leave a task in which they are absorbed.

Dr. O. C. Gibbs (*Pennsylvania and Independent Medical Journal*, ii., p. 12, 1859) relates the history of a large, muscular man, aged fifty-five, who showed, in a permanent and exaggerated form, this kind of automatic condition. The person in question had been a hard drinker and smoker, but had suffered from no disease. His family at last noticed, however, that his mind was somewhat affected. His memory failed, and he would tell the most absurd stories. Gradually his intelligence diminished and his will became impaired. When he began to do a certain thing he had no power to stop himself. If he went to the barn to throw down hay he would never stop, unless interfered with, until he had pitched off the whole mow. If sent out to bring in an armful of wood he would never stop until the pile was all in, or the room was full. When he once commenced to eat, it seemed as if he could never cease. As his mind became more affected he gradually lost the power of balancing himself, and showed a constant tendency to go backward when standing, and to tip over backward when sitting. He slept much. His strength gradually failed, and he died with no marked symptoms. The diagnosis of cerebral softening was probably correct, although no post-mortem examination was made.

The Cerebral Automatism of Insanity.—The condition of cerebral automatism has been described as a form of insanity. But, on the other hand, there are forms of insanity in which cerebral automatism appears as part of the phenomena of the disease. Thus, maniacal states, especially those of epilepsy, and the impulsive acts in the various states of defective mental inhibition, may be looked upon as automatic.

Perhaps the automatic cerebral life in the insane is best shown in acute dementia, in which disease only the lowest of the mental functions remain, and the sufferer is guided only by the impulses and stimuli of his vegetative system.

In secondary dementia, and in idiocy and other states of mental enfeeblement, the mental activities, so much as remain, are more or less automatic.

Medico-Legal Relations of Cerebral Automatism.—In conclusion, I have only space to call attention to the very evident medico-legal importance of a knowledge of cerebral automatic states. This applies especially to the more frequently occurring forms, such as those of artificial, epileptic, and possibly inebriate, automatism. There is no doubt that a cerebral automatic is irresponsible, morally, for his acts, and except in inebriate automatism, the courts would sustain the medical view. Unfortunately, it is as yet practically almost impossible to demonstrate by objective tests that an accused person was really in an automatic state.

Charles L. Dana.

AUTOPSIES.—(Synonyms: Post-Mortem Examination; necropsy; Latin, *Autopsia cadaverica, sectio, obductio*; French, *nécropsie, autopsie cadavérique*; German, *Leichenschau, Section, Obductio.*) An examination of the body after death, to investigate the condition of the various parts of the body, to note any changes in the organs, and to determine as far as possible the cause of any such changes.

General Considerations.—An article intended, as this is, to aid the general practitioner in making a post-mortem examination would fall short of the mark were it to give simply the various cuts to be made in order to expose and permit of the examination of the different organs. While it would be out of the question, in a handbook, to detail all the possible alterations in the viscera, and the method of their recognition, yet there

are several points, apart from the question of the cuts to be made, which deserve attention.

The sooner after death an autopsy is made, the better, as putrefactive changes modify the appearances of pathological as well as of normal organs.

In case an autopsy is to be held, the undertaker should be requested to postpone the injection of any embalming fluid until the examination has been made, as the preservative fluids modify considerably the appearances, owing to the coagulation of albumen and the alteration of color produced thereby. If for any reason the autopsy is to be made late, it is desirable, where this is possible, to have the body kept on ice.

FIG. 444.

What shall the physician take to the house, and what may he rely on finding there? He should take instruments, twine, a sponge, and a rubber sheet a yard square. The fewer instruments he can get along with the better; there is less to carry; fewer to soil, and less liability of leaving any behind.

One needs a stout knife from seven to nine inches in length, of which half belongs to the handle, half to the blade. The blade should be from three-quarters of an inch to an inch and a quarter in width, varying according to the length (Fig. 444).

Also a sharp-pointed scalpel and a medium-sized pair of scissors. A pair of small, probe-pointed scissors, as represented in Fig. 445, is very useful, though not absolutely necessary.

FIG. 445.

One needs also a pair of forceps (Fig. 446) and a large needle (a sail needle that can be bought at a hardware store for a few cents will answer the purpose).

Two other instruments, not absolutely essential, though very convenient, are the costotome (Fig. 447), a stout pair of shears for cutting the ribs when calcified, and the enterotome (Fig. 448), a pair of long-handled scissors having one blade terminating in a rounded, hooked end, used in opening the intestines.

This outfit will serve for any autopsy in which the brain and cord are not to be removed.

To open the head, a saw (Fig. 449), a chisel (Fig. 450), and a hammer having the handle terminating in a hook (Fig. 451) are necessary.

To remove the spinal cord, a chisel known as a rachitome (Fig. 452) is very useful, though the ordinary straight chisel will answer the purpose.


FIG. 446.

FIG. 447.

One of the first requisites in an autopsy made in a private house is cleanliness, and in no way is this so much aided as by having a good sponge; a medium-sized, soft, lamb's-wool sponge is the best. The physician should never rely on finding this article at the house, but should take one with him. After the autopsy it can be washed with soap and water, and is then ready for use at the next autopsy. The better the quality of the sponge the longer it will last and the better work it will do.

At the house there can be obtained the following articles: half a dozen newspapers, several pieces of old cotton cloth, a slop pail, and, if there be no running water, a pitcher of water.

The physician cannot be too careful to avoid wounding the feelings of the family in the house where the autopsy is made. A room left in a state of confusion, or the soiling of carpet, chairs, or utensils with drops of blood, not only gives offence to the friends, but often prevents the careless physician getting permission for autopsies in the future, as the family are very likely to give their neighbors an account of Dr. A.'s slovenliness.

FIG. 448.

In making an autopsy in a private house, it is often necessary to alter the position of table, chairs, or the like. Before any change is made, it should be the duty of the physician to take mental note of the arrangement of articles in the room, in order that, when the autopsy is finished, everything may be restored to its former place.

All articles required in making the examination should be obtained before the autopsy is begun.

The body will be found either upon a bed, with or without a board under it, or upon an undertaker's frame set on horses, or in an ice box. In any of these positions the examination can be made without moving the body, unless the head is to be opened, which cannot be done with the body in an ice box except the head be raised and supported above the level of the box.

FIG. 449.

The clothing covering the trunk should be torn down the middle line, in front, and drawn to either side. Newspapers should then be tucked in at the sides of the body, beneath the head and over the pubes, so as to cover the clothing, but to leave exposed the whole anterior surface of the trunk from the chin to the pubes. Should any fluid be spilled later, it will fall upon the paper and not soil the clothing.

FIG. 450.

The rubber sheet should be spread out on the floor near where the operator stands; the slop pail is to be placed upon it; the sponge should be moistened and be laid near the hand, ready for instant use; the instruments are to be placed upon a newspaper spread out upon the thighs of the corpse. All appliances are to be made ready before any cutting is done. Once a beginning is made, the performer's hands become so bloody that nothing can be touched later without soiling.

The physician should examine his hands carefully with reference to the presence of

of the diaphragm is reached, remembering to go, on the right side, to the outside of the falciform ligament of the liver. Put the forefinger of the left hand upon the external surface of the thorax corresponding to the position of the fingers inside. Withdraw the right hand and, beginning at the clavicle, count downward ribs and interspaces until the finger of the left hand, previously placed on the outside, is reached. This gives the position of the arch. Its usual position is the fourth rib on the right, and the fourth interspace or fifth rib on the left. It is lowered when the lung is solidified, and when there is fluid or gas in the pleural cavity. The fluid or gas may be so abundant as to bulge the diaphragm downward. (To determine presence of gas in pleural cavity, see later.)

The next step is the removal of skin and muscle from the anterior surface of the thorax, so as to lay bare the sternum, cartilages, and bony ribs for a distance of two to three inches outside the articular line.

The abdominal flap is seized in its upper part by the left hand, and turned forcibly outward; by doing this the rectus abdominis at its point of origin, the lower margin of the ribs, and the attachment of the diaphragm are exposed. The heel of the blade of the large knife is now placed upon the origin of the rectus, and by means of a single sweeping stroke, carried just above the lower border of the ribs, the rectus and the diaphragmatic attachments are severed. Then seize the flap a little higher up, turn it forcibly outward so as to put the muscles on the stretch, and divide the parts which have been made tense. Continue the cuts in like manner until the ribs on the right side are exposed, removing all the muscle with the flap so as to leave the ribs clean. Repeat the process on the left side. Then expose the sterno-clavicular articulation by dividing subcutaneously the tissues that cover it.

Before removing the sternum a general inspection of the abdominal cavity should be made, to note whether there be an increase in the amount of the serous fluid normally present, or abnormal contents. The reason for making the cursory examination at this stage of the autopsy is that if there be fluid in either of the pleural cavities, some of it will be likely to escape into the peritoneal cavity on removal of the sternum; hence it would be impossible to determine later whether fluid found in the abdominal cavity was there originally or had come from the pleural cavity.

If pneumothorax is suspected, the presence of gas in the pleural cavity should be determined at this stage of the autopsy. It is best done by making a double fold of the skin flap over the anterior portion of the thorax on the suspected side. Water is poured into the space between the folds, making a little pool. The sharp-pointed scalpel is now driven through the muscle of an intercostal space, where the water lies, and the effect noticed. If there be gas in the pleural cavity, it will escape by bubbling through the liquid; otherwise the water will disappear through the opening. One must not mistake the collection of gas from putrefactive changes in the pleural cavity for gas which has collected during life. If present from putrefaction, it will be double-sided, and there will be other evidence of putrefactive changes in the tissues.

The sternum is now to be removed. This is done by opening the sterno-clavicular articulation, and dividing the cartilages of the ribs about one-eighth of an inch from their junction with the bony ribs. The knife to be used is the small pointed scalpel already described. The guide to the position of the sterno-clavicular articulation is the tendon of the sternal attachment of the sterno-cleido-mastoid muscle. Insert the knife above the clavicle about one inch outside this tendon; then by an up-and-down motion divide the soft parts till the tendon is reached; turn the knife so as to enter the joint; then follow the joint in a semicircle, with the same up-and-down motion of the knife, not trying to guide it, so far as its vertical direction is concerned, for the plane of the joint is a constantly varying one; hence the importance of holding the knife loosely in the fingers and letting it take its own course. Do not remove the knife after the joint has been opened, but continue the incision outward along the under border of the clavicle for an inch outside the joint, then turn the knife at right angles to its former position and cut the first rib. In opening the sterno-clavicular joint, care should be taken not to carry the point of the knife below the inner part of the joint, as the innominate veins lie beneath and are liable to be cut.

The costal cartilages are to be cut in the place indicated above by a quick, forcible stroke with the scalpel, the heel of the knife striking upon the next rib below as the blade incises the rib. In this way the blade is prevented from going too deeply, and thereby injuring the lung. All the cartilages having been divided, the sternum is to be depressed below the level of the bony ribs and the intercostal muscles cut, the knife being held parallel to the ribs to avoid cutting the lung. Remove the sternum by lifting its lower end up, cutting the attachments of the diaphragm to it, and also the tissues of the anterior mediastinum, keeping as close as possible to the posterior surface of the sternum so as to avoid opening the pericardium. When the under surface of the sterno-clavicular joint is reached some difficulty will be experienced in removing the sternum, owing to the resistance offered by the firm ligaments of the joint, but by prying the sternum outward these ligaments are put upon the stretch, and can then be readily cut with the point of the knife.

The sternum having been removed, a general view of the anterior mediastinum should be taken, especially with reference to the presence of serous fluid or pus in its meshes.

Although the heart is the first organ of the thorax to be examined, yet the pericardium should not be opened until a cursory view of the pleural cavities has been taken with reference to the presence of fluid; for here, as in the peritoneal cavity, fluid present may have come from the pericardium, if that be first opened.

Open the pericardium by seizing the anterior portion of the parietal layer with the forceps and, lifting it up (if there be adhesion of the pericardial surfaces, as a result of earlier inflammatory processes, it will be made apparent by the inability to raise the anterior portion of pericardium), nick it with the scissors; cut upward as far as the reflection of the pericardium upon the aorta; then cut downward to the right and also toward the apex. The incision will have the form of an inverted Y. Lift up the heart and note the contents of the pericardium and its character (serum, fibrin, pus, blood). Also note the appearance of both pericardial surfaces. Examine the heart with reference to its size, shape, and the contraction of its walls. Then open the four cavities of the heart *in situ*, to determine the character and amount of their contents. The method is as follows: Let the heart rest upon the palm of the left hand, with the thumb upon the upper surface; turn the heart toward the left; this will make prominent the right auricle, and will bring into view the superior and inferior cavæ where they join the auricle. Make an incision into the auricle at right angles to the cavæ. Next turn the heart back to its former position; lift the thumb from the anterior surface and incise the right ventricle by a cut parallel and close to its right border, remembering not to carry the cut to the apex, as this is formed by the left ventricle only. Open the left ventricle by an incision along the left border a little to the right of and parallel to the coronary vessels. To open the left auricle, put the forefinger in the cut in the left ventricle and the thumb into the cut in the right ventricle, then lift up the heart and carry it toward the right of the body; in this way the left auricle, with the two left pulmonary veins entering it, will be seen. Open the auricle by a crescentic cut, beginning in the upper vein, thence into the auricle, and outward into the lower vein. Introduce one or more fingers into the incisions and note the amount of the contents and their character. The left ventricle is contracted and empty, unless the individual has died from paralysis

with the pancreas and mesentery, must now be removed. To do this, the left lobe of the liver should be lifted up; the diaphragm cut through its middle as far down as the œsophagus; the œsophagus divided transversely about two inches above the stomach; the cut end compressed between the thumb and forefinger of the left hand; the stomach lifted and dissected away from the underlying tissues; the pancreas and mesentery dissected from the aorta and inferior cava, and the gastro-hepatic and duodeno-hepatic omenta divided. The whole gastro-intestinal tract, together with pancreas and mesentery, is now freed and can be removed from the body.

Although the examination of the intestines is usually postponed until the last, to avoid soiling other parts with its contents, yet the method will be given here. The gastro-intestinal tract should be opened its entire length, either with an ordinary pair of scissors or with an instrument which renders the operation far easier, the enterotome (Fig. 448), the hooked blade being introduced into the inside. The stomach is to be opened along the greater curvature, the reason being that the common lesions—ulcers—are usually situated on the lesser curvature. The small intestine should be opened along the mesenteric attachment, for the reason that Peyer's patches, the usual seat of typhoid and tuberculous processes, are situated on the opposite side. The large intestine is to be opened along one of the three tæniæ, or bands, the object being to avoid getting the point of the scissors caught in the pouches lying between the bands.

Much time can be saved by using the scissors, not in the ordinary way by opening and closing the blades, but by keeping the blades immovable and carrying the scissors forward with the right hand, at the same time drawing the intestine backward with the left hand.

The amount and character of the contents of the various portions of the gastro-intestinal tract should be noted; the mucosa is to be freed of its adherent material either by water, when this can be obtained, or else by the fingers, and the mucosa of the entire tract is then to be carefully examined for evidences of inflammatory processes—ulcers, perforations, or other lesions.

The stomach and intestines having been removed from the abdominal cavity, a view can be obtained of the kidneys, ureters, and bladder *in situ*—a point of value, as the relation of one to the others is often needed in explaining the association of lesions. It is the custom of the German pathological anatomists to remove the kidneys before the intestine, hence at a stage in the autopsy when it is impossible to get a view of the urinary tract in its continuity. It seems to the writer that nothing is gained by removing the kidneys before the intestine, but that much may be lost; for if one finds, as the kidneys lie *in situ*, that they present changes, it may be very advantageous to remove them with the renal artery and aorta, on the one hand, as in cases of atrophy, especially when dependent upon a chronic interstitial nephritis, or, on the other hand, with the ureters and bladder and perhaps the penis, if there be hydronephrosis or pyelonephritis.

A general inspection of the urinary tract having been made as the parts lie *in situ*, one should then open the bladder by an incision from one to two inches in length along its upper wall. The amount and character of the contents, and especially the appearance of the mucous membrane, should be noted; for if there be evidence of an inflammatory process it will be desirable to remove the kidneys, ureters, and bladder in a single mass, owing to the fact that inflammatory processes in the mucosa of the bladder may extend upward through the ureters and involve the pelves of the kidneys and the kidneys themselves.

If there be no evidence of a cystitis, no further examination of the bladder is now to be made, but attention is to be directed to the kidneys. Inasmuch as these organs lie behind the peritoneum, it is necessary to cut this in order to get at them. The incision should be made just to the outside of the kidney along its convex border. The fingers of the right hand should now be introduced into the cut and the kidney "shelled out" of its perinephritic fat, lifted upward, the blood-vessels at the hilus cut transversely and traction made upon the kidney, which will strip up the ureter as far as the brim of the pelvis, where it may be divided. The suprarenal capsules may either be removed with the kidney or may be left *in situ* until a later stage of the examination. On the right side it is less easy to remove the suprarenal capsule with the kidney than on the left, owing to its closer adhesion to the under surface of the liver.

The examination of the kidney consists in noting its size, shape, color, and density; and in the removal of the capsule, observing whether it comes off easily or with difficulty, also whether portions of renal substance adhere to it. An incision in the kidney is made by holding the organ between the thumb and fingers of the left hand, with the hilus resting upon the palm, and cutting along the whole convex border through the kidney to and into its pelvis. In the examination of the cut surface the ratio of cortex to pyramids, as to thickness, should first be noted, and then the cortex studied with reference to the appearance presented by the glomeruli and the regions of convoluted and straight tubules. The degree of injection of the vessels of the cortex and pyramids, as determined by the color, is to be observed; then the mucous membrane of the pelves is to be examined; finally, the ureters are to be opened. If there be evidence of atrophy involving one or both kidneys, the corresponding renal artery should be opened to the aorta to determine whether the lumen is narrowed from chronic endarteritis.

The next step in the autopsy is the removal of the pelvic organs, either with or without the external genitals. In the female, the external genitals should be removed with the internal genitals in cases of death following puerperal fever or abortion; in the male, when there is a suspicion of stricture or wound of the urethra, or of a periurethral abscess.

In case it is not necessary to remove the external genitals the method of procedure for removal of the pelvic organs is as follows: Sweep the knife around the true pelvis, keeping as close to the bony wall as possible; in this way the loose connective tissues will be severed. Seize the bladder by its upper portion and draw it backward, away from the pubes; cut its attachments to the pubes, and then, while still making strong backward traction, cut the vagina and rectum transversely as far forward as possible. In this way the vagina as far as the hymen may be obtained. The same procedure, so far as the drawing back of the bladder and cutting its attachments are concerned, is to be carried out in the male, the prostate and rectum being then divided transversely as far forward as possible.

The removal of the external genitals connected with the internal pelvic organs is accomplished in the following way: The pelvic organs are freed from their surroundings as already described; then incisions are made on the outside, beginning at the lower end of the primary incision, which had been carried to the pubes, and carried to the outside of the labia majora on both sides in the form of an ellipse, the two cuts meeting again in the median line behind the anus at the tip of the coccyx.

The vulva is now dissected away from the pubes until the bony pubic arch is reached. The knife is then to be inserted beneath the pubic arch with the blade close to the bone, and then pushed into the cavity of the pelvis so that its point can be seen. With the knife held horizontally, it is swept around in the two curved incisions described above until the coccyx is reached. This will free the attachments to the pubic arch anteriorly and laterally, and to the coccyx and lower part of the sacrum posteriorly.

The external genitals are now to be drawn under the pubic arch into the cavity of the pelvis. This puts the attachments to the sacrum on the stretch, and gives a better view of the parts that still require to be divided in order wholly to free the organs in question.

In the male the penis may be removed with the internal organs by drawing the dartos toward the glands; cutting

with the scissors the small amount of connective tissue that holds the skin to the body of the penis; then dividing the penis by a transverse cut just behind the corona, unless it is thought desirable to remove the glans also, in which case the dartos should be cut circularly where it is reflected upon the glans, *i.e.*, in the corona. The attachments of the penis to the pubic arch are divided by transfixion, as in the female; the organ is drawn under the arch into the cavity of the pelvis, and the adhesions to surrounding parts divided.

If there be anything abnormal about the perineum, it is desirable to remove with the penis and pelvic organs an elliptical or lozenge-shaped portion of skin, its anterior apex being just behind the scrotum, having its posterior apex at the coccyx. This will include perineum and anus. The removal is accomplished by transfixing with the knife held in a horizontal position, the point being carried well into the pelvic cavity.

The further examination of the male pelvic organs consists in prolonging the incision, made in the bladder while *in situ*, to the urethra through the prostate with the scissors. If the penis has been removed, the incision should be continued along the dorsum to the meatus. The interior of the bladder and urethra can now be examined. Transverse incisions are to be made in the prostate. The vesiculæ seminales and the prostatic and vesical venous plexuses should next receive attention. The plexuses are of importance, as likely to be the seat of thrombi.

The rectum is now to be opened along its posterior wall, and the mucous surface examined.

In the female the bladder and urethra are first to be opened and examined. The vagina is then to be exposed along its whole length by an incision along its left lateral wall. In this way one avoids injuring the bladder. When the cervix is reached, the incision should be carried at right angles to its first direction, and the anterior wall of the vagina be cut transversely as far as the middle line of the uterus. The scissors are then introduced through the os into the cervical canal, and the uterus opened by cutting in the middle line anteriorly as far as the fundus. Counter incisions, beginning at about the middle of the body, are now to be made in the direction of the orifice of each Fallopian tube.

If the tubes are enlarged they should be opened with the probe-pointed scissors. In the normal tube the canal is so small that it is almost impossible to follow it out, and it is furthermore unnecessary.

The ovaries are to be opened by an incision beginning on the free, convex border and continued to the hilus, *i.e.*, to the broad ligament. The vaginal and uterine plexuses are then to be examined.

If death has occurred in the puerperal state or after an abortion, the external genitals and vagina should be examined carefully with reference to lacerations, and numerous incisions be made in the vaginal wall, extending into the perivaginal connective tissue, to determine whether a purulent lymphangitis is present.

In the puerperal uterus the inner surface is to be examined for evidence of an endometritis. The uterine sinuses, the pampiniform plexuses, and the ovarian veins are to be examined for thrombi undergoing septic softening. The tubes are to be opened to discover evidence of a purulent inflammation of their mucosa (salpingitis purulenta). Numerous incisions are to be made in the wall of the uterus for evidence of suppurative lymphangitis.

The examination of the testicles can be readily made, without injuring the scrotum, by pushing them upward through the canal, so that they will appear at the rings on either side. The peritoneum and then the tunica vaginalis are to be divided, and the testicle can be removed by severing the cord. It should be opened by an incision parallel to its long diameter, beginning on the side opposite the epididymis.

The liver is removed by cutting the ligaments. In noting the dimensions of this organ one should take cognizance of the relations of the right to the left lobe as regards size. The shape, color, density, and any points relating to the capsule are to be observed. The incision for examining the interior should be made transversely, beginning at the left border and ending at the right border. The appearances of the single lobules are now to be studied; the relative proportions of central and peripheral parts and the color of each being the important points to be observed.

The gall bladder is to be opened by an incision parallel to the long diameter.

The order in the examination of the organs of the abdominal cavity is to be varied in case of acute peritonitis. In making an autopsy one should not rest satisfied in finding evidence of acute peritonitis, but should always search for the cause. Of the causes, the most common are extension of an inflammation from the pelvic organs, this especially in the female; perforation of the vermiform appendix from appendicitis; and perforation of the gastro-intestinal tract at some part. In case of acute peritonitis, no organ should be removed until the *probable* source has been made out. This is done by lifting and separating the folds of intestine, and observing in which part of the peritoneal cavity the inflammatory process is farthest advanced. Then the parts may be dissected away from this organ, whichever it may be, and the attempt made to find the perforation or other lesion which is primary. The questionable organ may then be removed and further examined.

To proceed with the method ordinarily carried out. After the removal of the liver there remain in the cavity of the chest and abdomen the trachea and its bifurcation, the greater part of the œsophagus, the aorta, and the inferior cava. The aorta is to be opened *in situ*, with the scissors, along the anterior wall from the arch to the bifurcation, and then the iliac arteries are to be opened to the groin. The inferior cava and the iliac veins are also to be opened. These vessels are opened *in situ* that no injury may be done to thrombi if they be present within.

The aorta and as much of the trachea and œsophagus as possible are now to be removed by cutting the two latter as high up in the neck as they can be reached, and dissecting them and the aorta from the vertebral column, the aorta being attached to the vertebral column by a small amount of connective tissue.

The trachea is to be opened along its posterior wall (the cartilaginous rings being interrupted at this part); the œsophagus along the anterior wall.

The larynx and tongue may be removed with the lungs, or simply with the trachea. The knife is passed upward under the skin of the neck and the attachments of the trachea and larynx to the anterior, lateral, and posterior parts severed by sweeping cuts starting in the median line and carried to the side and then to the back. The attachments of the muscles of the tongue to the lower jaw are divided, the knife being carried up from below preferably to being introduced through the mouth. The soft palate is separated from the hard palate, and the pillars of the fauces are cut laterally so as to include the tonsils. The tongue is now seized with the fingers of the left hand passed upward through the neck and drawn downward, and the muscles and connective tissue holding the pharynx to the vertebral column are divided.

In this way the soft palate, tonsils, wall of pharynx, larynx, and upper part of œsophagus may be removed together, and a good opportunity afforded for their examination—a point of value in diphtheritic processes and the like.

The larynx should always be opened anteriorly.

The cavity of the trunk is now empty and a good opportunity is afforded for the examination of the bodies of the vertebræ, if there be anything in the case which renders such an examination desirable.

Unless the brain or cord is to be removed, the examination is now completed. Before returning the organs to the body cavity it should be sponged dry, and the pelvis packed with pieces of old cotton cloth to prevent leakage through the anus. After the organs have been put back the sternum is to be replaced and held by two stitches on either side, taken through the intercostal muscles.

The flaps are next brought into apposition preparatory to sewing them together. To do this take a piece of stout twine one and a half times the length of the incision; after threading it, take a stitch at the extremity of the long incision and tie a hard knot in the end of the string. For sewing, the glover's stitch is to be used, *i.e.*, from inside out. The stitches should be about three-quarters of an inch apart and three-eighths of an inch from the edge of the flap, taking up only the skin and subcutaneous tissue, but not the fat tissue. When the seam is finished a double knot is made in the string and the end drawn under the skin.

Certain final details will be considered after the method of removal of the brain and cord has been explained.

Method of Removal and Examination of the Brain.—Note the ratio of the head to the body, and of the cranium to the face.

Make an incision in the scalp, beginning half an inch behind the right ear, near its lower border, and extending over the middle of the vertex to the corresponding point behind the left ear. In women the hair should first be roughly parted, along the line where the incision is to be made, with the handle of the scalpel. After the incision has been started by cutting with the edge of the knife downward, it is best to reverse the blade so that its back comes against the bone and to cut upward. The incision is to be carried to the bone except in the temporal region, where it should be carried only to the aponeurosis covering the temporal muscle.

The anterior flap is first to be freed from the temporal muscle on either side, leaving the muscle attached to the bone, as it is through this that the stitches will be taken later that are to hold the calvaria in place. The flap is now to be seized by the left hand and strong forward traction made, while a series of sweeping cuts through the pericranial connective tissue are made with the scalpel held in the right hand. This dissection should be continued until the frontal eminences come into view. The posterior flap of the scalp is now to be dissected from the bone as far back as the occipital protuberance. While the scalp is being removed the condition of the loose pericranial tissues should be noticed with reference to evidence of œdema, hemorrhage, or purulent inflammation. The skull is now bare over the vertex, and note should be made of any abnormalities of its surface.

The next step is the removal of the calvaria. This is sometimes done by sawing through the skull in a circle; but this is bad practice, in that the calvaria cannot be later held firmly in place when it is sewn up—it will wobble. The best way is to saw along three lines to be marked in the periosteum, as a guide, with the scalpel. The first or anterior cut begins above and behind the ear, and is carried directly over the vertex to a corresponding point on the other side, the line passing just behind the edge of the hair above the forehead. The other two incisions in the bone are to begin, one at each end of the cut just described, and be carried backward to the median line behind, the two lines meeting at an angle of about one hundred and sixty degrees, well in front of the occipital protuberance. Each of these two lines just described should meet the anterior line at an obtuse angle in the temporal region.

If the hair be long it should be wrapped up in a towel, so as to form a ball, and the whole mass placed beneath the nape of the neck. This is to prevent the sawdust getting into it.

The calvaria is now to be sawn along the lines already marked, the head being steadied by placing the left hand upon the calvaria; a towel placed between the hand and the bone prevents slipping.

The incision in the bone should be carried through the outer table and diploë, and nearly through the inner table. One can readily determine when the saw has reached the diploë by the red color of the sawdust and the softer feel conveyed to the hand through the saw blade. What remains unsawn can be readily cracked with the chisel and hammer, placing the chisel in the incision and striking with the hammer a quick, sharp blow known as a recoil blow; this obviates the danger of driving the chisel into the brain.

If there be a suspicion of fracture of the skull, the incision with the saw should be carried through the bone and no cracking whatever done with the chisel and hammer.

The calvaria being now loosened, the wedge-shaped end of the hammer head is to be introduced in the middle of the anterior cut and pressed downward with the left hand, while the handle is rotated in the horizontal plane with the right hand. In this way a powerful leverage is obtained, and the calvaria can be forced backward sufficiently to introduce the hook on the end of the hammer handle into the cut in the bone. By pulling backward on the hammer the calvaria may be separated from the dura and so removed.

Generally the adhesion between the calvaria and dura is not a firm one, but occasionally in adults the separation requires the aid of the end of the enterotome, introduced between the dura and the bone and the two pried apart. Occasionally in old people, and always in young children, the adhesion is so firm that the dura has to be removed with the bone. This is accomplished by incising the dura along the incision in the bone and then cutting the attachment of the falx to the crista galli in the superior longitudinal fissure, when the calvaria may be drawn backward and the falx cut posteriorly.

After the removal of the calvaria, its thickness, the relation of diploë to tables, and the appearance of the inner surface should be noticed.

The examination of the dura is now in order. First observe whether the alternation of fissures and convolutions, as darker and lighter areas lying beneath, can be determined through it. If so, the dura has the normal degree of translucency, and is of the normal thickness. If this alternation of dark and light cannot be made out the dura is thicker than normal. Next open the superior longitudinal sinus and note its contents, whether fluid or coagulated blood or a thrombus. With scissors and forceps cut through the dura along the line of incision in the bone; then reflect it toward the median line so as to expose its inner surface. The presence of hemorrhagic or pigmented false membranes or patches is the important pathological condition to be looked for here.

The knife is now to be introduced into the superior longitudinal fissure, the dura drawn backward, and the attachment of the falx to the crista galli severed. The dura can now be drawn backward as far as the posterior incision in the skull; it should not be cut off, but should be allowed to hang down. The veins of the pia, where they enter the superior longitudinal sinus, offer slight resistance to the removal of the dura. They may be divided with the knife or scissors or else torn.

The greater portion of the convexities of the brain is now in view. One should note, in connection with the pia, the degree of fulness of its blood-vessels; whether it is translucent or opaque; whether abnormally dry; whether its meshes contain clear serous fluid, and, if so, the amount; also whether there be fibrin or pus in its meshes. One should then note whether the brain fills the cavity of the skull; also the relation of the convolutions to the sulci as to proportionate size.

The brain is now to be removed from the skull. Insert the two forefingers between the dura and the frontal lobes on either side of the median fissure and hook them around these lobes; draw backward on the brain until the optic nerves can be seen; then making slight traction backward on the brain by two fingers of the left hand hooked around its tip, cut across the cranial nerves and carotid arteries close to their foramina until the tentorium is reached; cut the latter close to its attachment to the petrous portion of the temporal bone. Next divide the cranial nerves given off from the medulla oblongata. Then carry the knife as far down in the vertebral canal as possible, and cut the cord by an inverted V-shaped cut, starting in the median line, and cutting first to the right, then to the left. The vertebral arteries are divided by the same stroke.

The brain is now readily removed by hooking the fingers of the right hand under the cerebellum, supporting the brain from behind with the left hand, and then lifting it out by the same turn employed in delivering the aftercoming head in a breech presentation.

The further examination of the brain is to be postponed until the basal portion of the cranial cavity has been looked at. The lateral sinuses are to be opened and their contents noted. If there be a suspicion of a fracture the whole of the dura is to be stripped off, it being usually impossible to discover a fracture of the base while the dura is *in situ*.

The posterior part of the eye may be exposed and removed by chipping away with the chisel the thin orbital plate which forms the roof of the orbit and the greater part of the floor of the anterior fossa.

The middle ear can be exposed by chipping off its roof, which lies in the middle of the petrous portion of the temporal bone. If the inner ear is to be examined, the whole petrous bone must be sawn out by a **V**-shaped incision in the squamous portion of the temporal, the apex of the **V** extending below the external meatus.

The mastoid cells can be opened either from the inside of the skull or from the outside.

An excellent view of the nares can be obtained by removing those portions of the ethmoid and sphenoid lying in the middle line, from the cribriform plate of the ethmoid in front to the posterior clinoid processes behind.

By removing the basilar process of the sphenoid and the sphenoidal process of the basilar, the so-called clivus Blumbachii, an excellent view of the pharynx and larynx can be obtained.

The examination of the brain is now to be resumed. If it is desired to weigh it, this should be done before it is incised. The brain is placed upon the convexities, the base uppermost. The pia of the base is to be examined especially for evidence of inflammation or tuberculosis. The blood-vessels should then receive careful attention —first the circle of Willis, then the vertebrals and basilar, then the anterior cerebrals. The fissure of Sylvius is now to be opened by cutting the pia that forms a bridge across the fissure from the frontal to the temporal lobes, and the branches of the middle cerebrals followed out as far as the island of Reil. These are the most important of the cerebral vessels, owing to the liability of lodgment of emboli in them and because they supply the larger and most important part of the brain. Evidences of endarteritis should be looked for, and the vessels opened with the probe-pointed scissors. Emboli or thrombi, if present, can now be readily discovered.

This examination completed, the brain should be placed upon its base and the incisions made to open the lateral ventricles. This is a curved incision following the direction of the ventricle, the convexity being inward, the anterior end about the middle of the frontal lobe, the posterior end near the middle of the occipital lobe, the middle of the curve about a quarter of an inch from the longitudinal fissure. The hemisphere should be supported by placing the fingers of the left hand under the base and the thumb of the same hand in the longitudinal fissure, lifting the hemisphere upward. This serves to separate the roof from the floor of the ventricle.

The anterior portion of the cut should be deep, made with the knife held at an angle of forty-five degrees, point downward (to reach the anterior horn). The middle portion of the cut should be less deep, made with the knife held horizontally (so as not to injure the floor of the ventricle). The posterior cut should be deep, made with the knife held at an angle of forty-five degrees, handle downward (to reach the posterior horn).

One lateral ventricle having been opened, the brain is to be turned half around and the other lateral ventricle opened in the same way. The knife is now introduced in the foramen of Munro, and an incision is made vertically upward through the anterior pillars of the fornix and the corpus callosum. The posterior portions of the fornix and corpus callosum are now drawn backward as far as possible. By so doing the velum interpositum and choroid plexuses are brought into view. These are also to be drawn backward, thus exposing the third ventricle. The right posterior pillar of the fornix and the adjoining brain substance are now cut transversely and carried over to the left. This procedure exposes the corpora quadrigemina. The fourth ventricle is now to be opened by an incision made through the middle line of the cerebellum, from above downward, at the same time dividing the corpora quadrigemina and valve of Vieussens by extending the median cut to the aqueduct of Sylvius.

The whole ventricular tract is now exposed to view. Note should be taken of the size of the ventricles, the character and amount of their contents, and the condition of the ependyma.

The hemispheres are next examined. In doing this it is essential to expose as large an area of white and gray matter as possible, but without disturbing the relations of the parts. The first incision is a curved one just to the outside of the basal ganglia and following the line of their outer borders. It should extend near to the pia below. A series of cuts are now to be made, each succeeding cut being made in the middle of the preceding cut and extending to, or nearly to, the pia. In this way the hemisphere is rolled out, unfolded as it were, and a large surface or series of surfaces is exposed to view. The pia is to be left uninjured, serving as a binding to retain the parts in their normal relation; so that, if a lesion be discovered in the white or gray matter, the parts may be replaced and the situation localized as to convolution.

The basal ganglia (corpora striata and thalami optici) are now to be examined by means of a series of transverse incisions, the cuts being about one-twelfth of an inch apart. These are most readily made by supporting the ganglia by one hand placed underneath, while with the knife in the other hand the cuts are made and the slices turned to one side so as to expose the cut surface. The necessity of the numerous incisions in the basal ganglia is owing to the fact that lesions sufficient to lead to a fatal result are often small, and might go unobserved were the incisions made far apart.

The cerebellum is now to be examined by a primary incision beginning in the middle of the cut made in it in opening the fourth ventricle and extending through the greatest breadth of the organ. This divides it into two equal portions, exposing a large surface of gray and white matter and the arbor vitæ. A series of radiating, fan-shaped incisions should then be made in each of these lateral portions, the cuts extending to the pia.

The pons is now to be lifted by the left hand placed beneath it and a series of transverse incisions is to be made, beginning anteriorly in the corpora quadrigemina and crura cerebri and extending through pons and medulla to the spinal cord. As in the basal ganglia, so here, the slices should be as thin as possible, that even a minute lesion may not escape observation.

The remaining step in the examination of the brain is to strip the pia from the convolutions of the organ, especially on the convexities, and note whether it is readily removed or whether it comes away with difficulty and removes portions of brain substance with it, leaving a worm-eaten appearance of the cortex beneath. Such an adhesion indicates a meningo-encephalitis, common in dementia paralytica.

The examination of the brain being now completed, the cavity of the cranium should be sponged dry and filled with a sand bag, made by taking a piece of cotton cloth eighteen inches square and putting on it as much house sand as corresponds, in the judgment of the operator, to the capacity of the cranium; then gathering the corners into a mass and tying them together with a string. A sand bag serves the double purpose of giving weight to the head and supporting the calvaria. The calvaria is to be replaced and held there by stitches taken through the temporal muscle on either side, care being taken to draw the twine tight to prevent slipping

of the calvaria. The two flaps of the scalp are now drawn together and sewn, after the method described in connection with the body. The seam requires a piece of twine twice the length of the incision.

Examination of the Spinal Cord.—To remove the cord the body should be placed face downward, with a block under the thorax. An incision is made along the ridge formed by the spinous processes of the vertebræ from the occiput to the sacrum. The skin together with the muscles filling the vertebral grooves should be dissected from the arches, leaving the laminæ bare. The laminæ are now sawn nearly through in a line with the roots of the transverse process. By means of the straight chisel, or, better, with the rachitome (Fig. 452) and the hammer the arches are freed and then pried off. The arches of the upper cervical vertebræ are best divided with the costotome (Fig. 447).

The membranes and cord are now divided transversely at the lower end; the dura is seized with the forceps and the cord lifted upward, and the spinal nerves are divided with the scalpel close to the foramina. When the atlas is reached the cord is held only by the dura, where it is reflected on the margin of the foramen magnum to become the periosteum of the inner surface of the skull. This is divided by a circular incision a little below the foramen magnum. The cord is now free.

The dura of the cord is now incised anteriorly and posteriorly throughout its entire length, and its inner surface, as well as the pia of the cord, examined.

The cord is examined by a series of transverse incisions half an inch apart, the pia on the anterior surface being left intact to serve as a binding to hold the parts together. The incision in the back is to be sewn up in the same way as the one in front.

Cultures of bacteria from the blood are best made from the right ventricle of the heart. The surface of the right ventricle is sterilized by a case knife heated in a Bunsen lamp, laying it flat on the surface of the heart. An incision is made through the wall with another knife sterilized in the same way, and the platinum wire introduced through the cut and the culture made.

Cultures from any of the solid organs may be made in the same way.

The examination of the whole body being now completed, the soiled newspapers are to be removed and burned in the furnace or kitchen fire. The operator should himself attend to the emptying of the slop pail, which will contain bloody fluid and more or less intestinal contents; and should also see that all utensils are thoroughly cleaned, that all spots of blood are removed from the body, and that the body is restored to the position it was in before the autopsy was begun.

A word as to the report of the autopsy. A proper report should consist of two parts. The first, to consist of a description of what is seen, should be purely objective, and should contain no expression of opinion. The second part is to contain the anatomical diagnosis; in other words, the inferences drawn from the appearances presented by the organs.

If the report consists (as unfortunately it so often does) simply of the inferences of the operator, without a description of the appearances upon which those inferences are based, it is of little value to any one else, and of no value as evidence.

Let the physician, then, in his report, describe to the best of his ability what he sees, and if he is in doubt as to what the meaning of the appearances is, any specialist taking his report can give him much more assistance than if the inferences only are stated.

W. W. Gannett.

AUTOPSIES, MEDICO-LEGAL RELATIONS OF.—

General Consideration.—When death is due to other than natural causes, the data upon which such a conclusion is based may become the subject of legal inquiry. This article concerns itself with such data as may be furnished by the performance of an autopsy. The lesions found, the method of their observation, and the deductions to be drawn therefrom are the subjects for discussion.*

"Natural cause of death," is rather difficult to define tersely. The importance of its full comprehension is apparent, not only to avoid error in reaching such a conclusion, but also from the fact that an effort to show the evidence, including data from the autopsy compatible with natural causes, is frequently made by the defence. "Senile changes or disease unassociated with poisoning or traumatism," although it might answer in the majority of cases, is nevertheless faulty, as the following considerations show. The acute infectious diseases accepted as natural causes are all associated with poisoning from the toxins produced by the bacteria. Even the acute infectious diseases may come under the category of unnatural causes if the bacteria are accidentally or deliberately inoculated.

Accidental inoculation of bacillus mallei (glanders) has caused a number of deaths in bacteriological laboratories, and the deplorable cases of death from accidental inoculation of the bacillus of bubonic plague in a laboratory in Vienna furnish additional examples of acute infectious diseases in which the cause of death can by no means be considered natural. The deliberate ingestion or injection of a pure culture of pathogenic bacteria with suicidal or homicidal intent might occur. The ingestion of a pure culture of typhoid bacilli with suicidal intent, followed by typhoid fever and recovery, has come to notice. Again, the pathological changes following the long-continued ingestion of alcohol in excessive amount are looked upon as natural causes, although they are certainly the products of poisoning. Erysipelas and tetanus are invariably produced through some solution of continuity in the skin or mucous membrane, in some cases so slight that no notice may have been taken of it, nor can it in some cases be demonstrated at autopsy.

If we adopt the above, with these restrictions, as a working definition, it becomes necessary in examining lesions to differentiate between those produced by disease and those produced by poisoning or traumatism. Nor is this an easy matter, as might at first appear. A lesion apparently traumatic may be due to disease. Lesions apparently due to disease alone may prove to be dependent upon trauma primarily, as when infection follows a wound. Again, a diseased condition (as cerebral arteriosclerosis, or pachymeningitis hæmorrhagica) may be an important contributing cause (vertigo) of an accident in which traumatism is sustained, causing death; or the diseased condition may directly predispose to a result (fatal hemorrhage) out of proportion to the comparatively slight traumatism. Finally, traumatism and disease not dependent in causation upon one another may both contribute more or less equally in causing death. The lesions of disease may so closely resemble the effects of poison (in the toxicological sense) that their differentiation by gross examination is almost impossible, chemical and bacteriological examinations being necessary to clear up the case. The occurrence of this similarity is not strange, when we remember that many of the lesions of infectious diseases are due to poison, namely, the bacterial toxins.

Technique.—The method of observation includes the technique employed in the performance of the autopsy. Not only the data and the deductions drawn therefrom, but the way in which these data were acquired may be subjected to searching investigation in court. By faulty methods incorrect data may be obtained. Direct mistakes in observation are not here referred to, but unintentional and unobserved artifacts, and their diagnosis as lesions. It is absolutely necessary to be fully cognizant of all methods and manipulations by which such artifacts may be produced, not only to avoid them, but also to be able to testify to that effect. In considering the technique of medico-legal autopsies only these points will be dwelt upon.

* For signs of death, rigor mortis, putrefaction, etc., subjects embraced in an external examination of the cadaver, see *Cadaver, Legal Status of.*

Head.—In removing the calvaria the bone should be sawed through completely. The wedge, or chisel and mallet, had better not be used. Although the physician may be certain that a fracture was produced during life and not post mortem by use of chisel and mallet, yet if their use is admitted a reasonable doubt may be cast upon his testimony. The brain should be removed with special care, raising the frontal lobes sufficiently to cut nerves and vessels close to the foramina of exit and, raising the temporal lobes, to sever thoroughly the anterior and lateral attachments of the tentorium, first on one then on the other side, and divide the remaining nerves and vessels below, in doing which the brain should not be raised from the base of the skull more than necessary. After division of the tentorium the brain should be supported, as the final division of nerves, vessels, and spinal cord proceeds, lest by its own weight dragging upon these structures, it causes artificial lacerations. The brain should be perfectly free before its removal is attempted, and should be allowed to slide backward, the convex surface resting in the palm of the hand.

Spinal Cord.—To avoid artifacts a complete division of the laminæ on either side, 1 cm. from the spinous process, should be made with a straight saw curved on the end, the serrations extending a short distance upon the curve. Chisel and mallet had better be avoided. Test the complete division by pressing each spinous process from side to side. If free, the laminæ and spinous processes can readily be removed together from below upward, by grasping the lowest and using the knife alone. After the attachment of the dura spinalis to the foramen ovale within the skull has been severed, the spinal cord should be removed together with its dural sheath, the spinal nerves being cut close to the intervertebral foramina on either side from below upward. The dura should be opened in the median line anteriorly and posteriorly after the removal.

Mouth and Neck.—The examination of the fauces and aditus laryngis is of importance, more especially in infants, great care being required to prevent occurrence of artifacts. The tongue, anterior and posterior pillars of fauces, tonsils, soft palate, pharynx, œsophagus, larynx, and trachea may be removed together. The incision is extended to the chin, or, after the thorax has been opened, they may be removed, without extending the incision over two inches above the episternal notch, by separating the skin from the clavicle and working up from the thorax, separating the unincised skin from larynx, hyoid bone, and muscles of the floor of mouth. Retraction of the skin by hooks or a finger of an assistant on either side in an upward direction gives ample room if the sternum and costal cartilages have been removed; and the space may be still further increased by partial incision of the sterno-cleido-mastoid muscle near or at its insertion to the clavicle. With a sharp-pointed knife the floor of the mouth is punctured in the median line close to the inferior maxilla, and the muscles and mucosa cut through along the body of the bone to the angle on both sides. The tongue is drawn down through the incision, and with the knife passed over the dorsum of the tongue, an incision is made through the soft palate close to the bone from the median line outward, then, anteriorly to the anterior pillar of the fauces, downward into incision through the floor of the mouth on both sides. The loose areolar tissue on either side of the trachea and larynx, œsophagus and pharynx, and posterior to the latter, is separated well up to the occipital bone, where the attachment of the pharynx is cut across. The styloid muscles are cut and the organs drawn gently downward, care being taken to observe whether there are any points at which attachments still require to be divided. It is possible for the stomach contents to reach the larynx or the aditus laryngis post mortem, either in moving the cadaver about or during the performance of the autopsy. During the removal of the stomach its contents may be forced into the œsophagus and pharynx and larynx. To guard against this a ligature should be applied to the cardiac end of the œsophagus before dissecting out the stomach.

Thorax.—In cases of hemorrhage, great care should be exercised so that its origin may be accurately determined, and its cause, whether traumatic or due to disease or possibly to both conditions, determined. The examination of the organs *in situ* should be made. To determine the presence of pulmonary thrombosis the pulmonary artery should be opened with organs *in situ*. If the examination is unsatisfactory, the organs of the thorax may be taken out together with those of the neck and mouth if necessary. Pleural adhesions having been separated, or if too dense (rather than risk an artificial laceration of the lung), the costal pleura having been stripped off, the attachments of the diaphragm cut away from the ribs, and its pillars severed, an incision is made through the parietal pleura along the vertebral column external and posterior to the aorta on the left side, the lung being brought forward for that purpose, and the left subclavian vessels, common carotid, and jugular are cut. On the right side the incision is made external and posterior to the vena cava superior, right auricle, vena cava inferior, and the innominate artery and vein are cut across. The œsophagus near the cardia is ligated and cut above the ligature. The aorta, inferior vena cava, and suspensory ligaments of the liver are then severed. By this technique injuries may be clearly demonstrated which by the usual technique might escape observation, or, if observed, their origin or relations might be doubtful.

Abdomen.—The abdomen should invariably be opened before the thorax, the skin and muscles of the latter being dissected off to give more room for inspection. The height of the vault of the diaphragm in the mammillary line on either side should be determined. The organs should be examined as far as possible *in situ* and the contents of the peritoneal cavity, if any, its character, amount, and distribution noted. In cases of injury special care is to be taken in the removal of organs, the incisions necessary being deliberately and cleanly made and laceration of tissue avoided. In cases of bullet and stab wounds their site should be accurately determined and their measurements carefully made so that the direction of the course of the bullet or knife may be determined. The abdominal organs may be removed together with the thoracic organs and diaphragm, in order to determine more accurately the relations of certain traumatisms. The œsophagus, aorta, vena cava, and ligaments of the liver are not divided. An incision is made through the parietal peritoneum on the right side external to the right kidney and ascending colon, on the left side external to the left kidney, descending colon, and sigmoid flexure. The loose connective tissue between the organs and the posterior abdominal wall is readily separated by blunt dissection, the lumbar branches of the aorta and the common iliac vessels requiring the knife.

Pelvis.—The pelvic organs may also be removed together, the connection of ureters with bladder and the sigmoid with rectum remaining intact. The female genital organs, after examination *in situ*, should be removed together. A circular incision is made through the peritoneum around the margin of the true pelvis, the loose areolar tissue stripped up with the fingers down to the levator ani et vaginæ, and anteriorly well down behind the symphysis pubis. With a few sections of the knife the ostium vaginæ together with the urethra, the bladder, vagina, uterus and appendages, and rectum are removed. After examination of the rectum, bladder, urethra, and the appendages, especially the ovaries for a corpus luteum of pregnancy, the vagina is laid open with knife or scissors. The cavity of the uterus should not be opened by thrusting the blade of the scissors or knife into it. A clean incision should be made in the median line posteriorly until the cavity is reached so as to avoid all chances for the occurrence of artificial laceration or puncture.

Cases of suspected poisoning require special consideration. The presence of the chemist at the autopsy and his direct reception of the organs for examination from

the pathologist simplify matters considerably. If this plan cannot be followed, it devolves upon the pathologist to remove such organs and fluids in which the suspected poison may be detected, in such a manner as to avoid contamination, and to place them in possession of the chemist with the least possible delay and by as direct means as circumstances will allow. It should be remembered that every step from the performance of the autopsy to the reception of the material for examination by the chemist may be made the subject of a searching examination in court, namely, how the organs were removed, what instruments were used and what condition they were in, what receptacles the material was placed in for transportation, how these receptacles were treated before and after the material was placed in them, whether any preservative fluid was used, were they properly sealed, and what means were employed in transporting them to the chemist. These points may appear trivial, yet too much attention cannot be paid to the minutest detail. Carelessness in this regard may nullify the entire work of the chemist and cause a break in an otherwise intact chain of evidence. On the other hand, such carelessness may be the means of unknowingly convicting an innocent defendant. Glass jars that have been used for no other purpose, carefully cleaned with soap and water, rinsed with water, then with alcohol, closed preferably with a ground glass stopper or clean, well-fitting cork, should be used. Stomach or intestinal contents, urine, and blood should be placed in separate jars. When the determination of the amount of poison in individual viscera is of importance they should be placed in separate jars. The condition of preservation or decay of the material should be noted. If the material cannot be placed in the hands of the chemist directly, a sufficient amount of strong alcohol should be added to cover the organs in the jars, in order to check decomposition and prevent breakage by the gases of decomposition. If this is done a portion of the same alcohol that was used in the jars should be sent to the chemist also. Finally all jars should be separately tied with tape, properly sealed and labelled. By this means, although the material may have necessarily passed through several hands, provided it reaches the chemist with intact seal, the chain of evidence, so far as the examination of the organs, fluids, etc., is concerned, remains unbroken.

Cases of Poisoning.—The evidence already at hand before the performance of an autopsy may point to a given poison as the cause of death, either from the clinical history of the case, or from the discovery of the empty poison bottle or package, or of some of the poison suspected to have been given to or taken by the deceased. This evidence, although a valuable guide, cannot be entirely relied upon and should not bias the judgment of the pathologist. Cases occur in which an entirely different poison is found to have been the cause of death, and some in which the presumptive evidence appeared very strong have proved to be deaths from natural causes, or the alterations found have turned out to be merely postmortem changes. Cases occur in which there is no suspicion whatever, and yet poisoning is proved by autopsy and chemical examination. Such are not merely cases of sudden death without any clinical history, but often enough cases that have been ill for some time and treated for disease by a physician, competent enough comparatively, who may have filed a death certificate giving the disease diagnosed by him as the cause of death. In fact, it is well known that the results of some poisons may so closely resemble disease clinically and even pathologically that mistakes can easily be made. The only safe way to avoid error is for the clinician to insist upon an autopsy before signing the death certificate, and for the pathologist to employ chemical and bacteriological aid. In the performance of autopsies, whether poisoning is suspected or the cause of death is unknown or doubtful, a complete examination of the body should be made; and the pathologist should be ever mindful of those conditions, although often resembling the results of diseases such as cholera, dysentery, nephritis, malignant jaundice, or acute yellow atrophy of the liver, which may nevertheless be the results of poisons such as arsenic, mercury, potassium chlorate, or phosphorus.

Some poisons produce no characteristic changes in the tissues of the body, so far as gross or even microscopical examination is concerned; their presence cannot be positively affirmed until chemical examination is made. The pathologist may, however, be able to state that no pathological condition of the organs due to disease or traumatism, and sufficient to cause death, has been found. When the organs are found in a normal condition it may be easy enough to reach this conclusion. When, however, pathological changes are present, it is often very difficult to estimate their importance in the causation of death. Although our knowledge of the morphology of disease, and of the bacteriology of many of the infectious diseases, is extensive, that of its chemistry is not nearly so well advanced. Pathological conditions are found which in the absence of any suspicious circumstances are assumed to be the cause of death; yet we meet with cases in which these conditions are present and may even be very pronounced, but nevertheless death is the result of violence or of some other intercurrent disease. When the circumstances of a death are suspicious, a chemical examination is usually called for. There are cases, however, of sudden death in which no suspicions are entertained at the time, but in which, though a careful autopsy is performed, a conscientious pathologist cannot satisfy himself of the cause of death, even with the aid of microscopical and bacteriological examinations. In such cases a chemical examination alone can affirm or exclude poisoning.

Other poisons do produce effects more or less characteristic by their direct local action, by their absorption, and by their excretion. The task in the performance of the autopsy is to determine whether the changes found may have been produced by a poison, and if possible by what poison. Of course, the positive proof in every case must be furnished by chemical examination. The work of the pathologist, however, is of importance, on the one hand to obviate useless chemical examinations, on the other to insist upon a chemical examination when necessary, and to select such organs and fluids of importance for examination. On this account it is important to know what changes are characteristic of poisoning, and what are characteristic of special poisons.

Certain physical characteristics of poisons may lead to the suspicion of their presence. A green color may indicate the presence of aceto-arsenite of copper; yellow, potassium chromate or iodine; blue, sulphate of copper; or certain dyes, as such used in corrosive sublimate tablets, or in the heads of matches, may furnish an indication. The odor characteristic of phosphorus, or of bitter almonds, of alcohol, of chloroform, of laudanum, or of carbolic acid may furnish an indication. The granular or crystalline appearance of the substance, its insolubility, may furnish a clew. The chemical reaction, whether acid or alkaline, is important, and the contents of stomach and intestine should always be tested in this regard.

In the greatest number of poisoning cases, the poison is introduced by way of the mouth; unusually, by rectal, vaginal, intra-uterine, or hypodermatic injection. Some poisons produce no effect upon the mucous membrane; others are irritants and cause effects varying in intensity from congestion and ecchymoses to complete corrosion with production of eschars. Those poisons which produce the corrosive effect upon the mucosa may act either by coagulating its albuminous constituents—as happens in the case of the mineral acids, oxalic acid and carbolic acid, and mercuric chloride—or by dissolving them and causing a swelling and softening of the mucosa—as is true of sodium, potassium, and ammonium hydrate and potassium cyanide. Concentrated sulphuric acid dissolves coagulated albumen; if dropped on a mucous membrane a spot is formed that is transparent in the centre and white at the periphery where the acid has been diluted by the fluid of the tissue and the albumen precipi-

tated. When the caustic alkalies have acted upon a mucous membrane, if neutralized or if the reaction is changed by addition of acid, the albumen is precipitated and a grayish eschar appears.

These effects may be further changed in appearance by the action of the poison upon the blood with which it comes in contact. If the poison separates hæmatin from hæmoglobin and dissolves it, the eschar or the tissue may be discolored brown or brownish black by imbibition, as with sulphuric acid, hydrochloric acid, oxalic acid, and the caustic alkalies. Carbolic acid and corrosive sublimate coagulate blood but do not cause a separation of hæmatin. Each, however, produces a change of color in the coagulum, namely, carbolic acid a bright brick red, and sublimate a grayish violet.

The effects may vary according to the amount of the poison, its concentration, the duration of its action, and the condition of fulness or emptiness of the stomach and intestines. The lips and skin of the face and neck may show corrosive action of the poison. The mucous margin may present grayish-white or brownish eschars. Crescentic streaks on either side of the upper lip, extending upward from the corners of the mouth, may be present when the poisonous fluid has been imbibed from a tumbler; there may be streaks from either corner of the mouth passing downward over the cheek or chin, and down the neck, when the poison has been spilled while drinking. Corrosion of the lips and skin may be absent when the poison has been swallowed from a bottle. The mucosa of the mouth may show swelling and eschars, but from short duration of contact these may not be well marked. The mucosa of the œsophagus may show little action from the short duration of contact and the relatively slight amount of poison that remains in contact.

The stomach usually shows the greatest amount of change. This may affect its entire surface, or be confined more especially to the region of the fundus, greater curvature, and posterior surface. Exceptionally, the corrosive action may be confined to the smaller curvature and anterior surface, the most probable explanation being the ingestion of poison upon a full stomach, which shortly thereafter has emptied its contents into the duodenum, in which case the duodenum and jejunum show the effects more markedly. The summits of the folds in the mucosa show more decided effect on account of greater exposure, the sulci being in part protected by contact of opposite surfaces. Thus the eschars in the stomach form longitudinal streaks separated sometimes by intervening mucosa not escharotic or less markedly so. The corrosive action varies in depth and may extend through the peritoneum, involving adjacent organs such as the spleen, colon, pancreas, and liver, without perforation of the stomach; or the stomach may have been perforated by the action of the poison, and its contents have escaped into the peritoneal cavity producing characteristic changes wherever the poison has come in contact. Autodigestion of the stomach with perforation may occur without the presence of corrosive poisons.

In the duodenum and jejunum the crests and superior surfaces of the valvulæ are especially exposed and show the greatest amount of corrosive action, usually more intense nearer the pylorus and becoming less severe further down. Exceptionally, the duodenum as well as the stomach may escape, and a coil of jejunum further along show severe corrosion. The ileum rarely shows the effect of direct local action, and the same may be said of the colon, except in those cases in which the poison has been introduced directly into the rectum. The caput coli and first portion of the ascending colon may occasionally show the effect of local action, probably from the longer duration of contact of poisons that have passed with greater rapidity through the small intestine. The colon and lower part of the ileum may show the effects of poison by excretion. This is a characteristic effect in bichloride of mercury poisoning, especially if a period of a week or two has elapsed after its ingestion.

The effects upon the tissues from the absorption of poisons is shown in the degenerative changes, parenchymatous or fatty, in the functional epithelial cells of the organs, as the stomach and liver; in the muscle fibre of the heart and sometimes of the voluntary muscles; and in the epithelium of the kidney, more especially of the cortex, when excretion of the poison has taken place.

Carbolic Acid Poisoning.—Eschars on the lips may be white, grayish, or, when drying has occurred, dark brown. The eschars on the cutaneous surfaces, if any, are usually brown, dry, and leathery. The mucosa of the tongue and mouth may be white or grayish white, or show no change. Pharynx and œsophagus usually show grayish-white eschars. There is generally more or less œdema of the aryepiglottic folds about the aditus laryngis and the loose submucous tissue over the arytenoids and anterior wall of the pharynx.

The eschars in the stomach are usually longitudinal, involving the crests of the folds, and of a white or grayish color, while the intervening mucosa, where not escharotic, will present a light red tint due to the action of carbolic acid on the blood. The entire wall has a dense leathery feel, and the stomach may be markedly contracted. The action of carbolic acid may extend to the peritoneal coat and even to the spleen and liver, the color usually being pink, or light red, upon a grayish-white base.

The distribution of effects varies according to the concentration and amount of the carbolic acid, and the condition of the stomach, whether empty or full when the acid was taken. The escharotic action may extend to a variable distance down the small intestine, the valvulæ of the duodenum and jejunum perhaps showing grayish-white eschars, while, further along, the mucosa may present a pink discoloration and marked swelling and softening. The other organs show but little change, in the great majority of cases, since death occurs within a few minutes. Passive hyperæmia is usually present. When cases have survived the ingestion of a smaller amount for some hours, the characteristic phenol urine is found, with marked parenchymatous degeneration of the kidneys.

Sulphuric Acid Poisoning.—The eschars on the lips and skin are usually brown, leathery, and dry. The mucous membrane of the mouth and œsophagus presents grayish-white eschars. The stomach wall is thick and dense, the mucous membrane corroded, the eschars brown or black from the imbibition of dissolved hæmatin. Wherever the blood has been acted upon, whether extravasated or in the vessels, the coagulum is black, dry, and brittle. Either from the action of the acid or from casting off of necrotic portions of mucous membrane the surface may present an irregular nodular appearance. The fundus of the stomach may be perforated either during life or post mortem, and wherever the acid comes in contact with tissue a cloudy appearance is presented, due to coagulation of albumin. The mucosa of the small intestine may present a variegated appearance of grayish-white eschars, where the acid has caused a coagulation of the albumin of the tissue, with intervening dark brown or black areas, where ecchymoses have occurred or where a previous eschar has exfoliated laying bare the submucosa stained with hæmatin. The kidneys show parenchymatous degeneration or nephritis. In prolonged cases the necrotic mucosa of the stomach and intestine may be thrown off, showing a hemorrhagic, œdematous submucosa, with more or less imbibition of hæmatin.

Hydrochloric Acid Poisoning. — Hydrochloric acid produces no corrosive action on the skin. The eschars are grayish-white when simple coagulation of albumin has taken place, and dark brown or black when ecchymoses have occurred or when imbibition of dissolved hæmatin has taken place. The effect is very much like that of sulphuric acid, except that the drying of the eschars and of the blood clot is less pronounced, owing to the fact that hydrochloric acid has not so strong an affinity for water.

Nitric Acid Poisoning.—The eschars present a yellowish stain, due to the formation of xanthoproteic acid; otherwise they are not markedly different from those described above, except as regards the fact that nitric acid

does not separate and dissolve hæmatin. The brown or black discoloration of the eschars present with both sulphuric and hydrochloric acids does not occur.

Concentrated Acetic Acid.—A case of poisoning from this acid is on record; death was due to pneumonia, and a grayish-white corrosion of the mucous membrane of the mouth and respiratory passages was observed. A sponge saturated with concentrated acetic acid was held at the mouth and nose.

Oxalic Acid and Oxalate of Potassium.—In concentration they produce white or grayish corrosion of the mucous membrane of the pharynx and œsophagus. The mucosa of the stomach is swollen, injected, and escharotic, with imbibition of hæmatin; it is easily removed by washing. The escharotic action, however, is never as great as with sulphuric acid. White opacities (oxalate of lime) are found in the blood of the corroded portions, also in the uriniferous tubules. Perforation of the stomach may occur, with the resulting effect of a local peritonitis, due to the escape of the contents of the organ into the peritoneal cavity. These perforations, however, are in most instances a post-mortem occurrence. Wherever the poison acts upon the blood, black clots occur in which oxalate of lime crystals may be found.

Caustic Potash, Soda, and Ammonia.—The mucosa of the mouth may be swollen and red, the epithelium partly exfoliated, partly still adherent in whitish shreds. The œsophagus may have lost its epithelium, and may be swollen and hyperæmic, its lower portion being brownish and soft. The mucosa of the stomach is thrown into thick folds, markedly swollen and ecchymotic, with superficial losses of substance; it is dark brown, from imbibition of hæmatin. The submucous tissue is markedly œdematous. Croupous gastritis may follow the action of the caustic. Croupous bronchitis and circumscribed areas of bronchopneumonia may result from aspiration of the caustic soda or potash and may be the immediate cause of death. In other cases the cicatricial tissue following the exfoliation of the sloughs may finally, if not relieved surgically, cause death by stricture of the œsophagus.

Carbon Monoxide Poisoning.—The appearance of the cadaver, in poisoning by carbon monoxide, is very characteristic, more especially in the cases of poisoning from illuminating gas. The post-mortem spots are of a pink hue, and give the cadaver an almost life-like appearance. The blood is fluid and cherry red in color. The mucous and serous membranes are of a rosy tint, and the organs (especially those containing much blood) present a cherry red appearance. This is especially well marked where the blood is seen upon a white background, as in the brain. The color should be determined at once as soon as the blood or organs are exposed to the air, as after a longer exposure blood that does not contain carbon monoxide hæmoglobin may become light red in color, the reduced hæmoglobin changing to oxyhæmoglobin, the oxygen being absorbed from the atmosphere. The appearance of the blood in some cases of carbon monoxide poisoning, although carbon monoxide hæmoglobin is present, may present a dark color from excess of reduced hæmoglobin, from carbon dioxide absorption. This occurs more commonly in poisoning from coal gas, and from inhalation of smoke at conflagrations. The appearance of the blood may also vary when several hours have intervened between the cessation of inhalation of carbon monoxide and death. Since vomiting is a symptom of carbon monoxide poisoning, cases may die, in an atmosphere of carbon monoxide, from aspiration of vomit, the formation of carbon monoxide hæmoglobin being as yet insufficient in amount to cause death.

Carbon monoxide hæmoglobin is readily demonstrated by the spectroscope, producing two absorption bands near D and E like oxyhæmoglobin, but not reduced like the latter by addition of ammonium sulphide. In doubtful cases, therefore, a specimen of the blood should be saved for this examination. It has been found that carbon monoxide hæmoglobin can be demonstrated in the blood of extravasations and in muscle when its demonstration fails in the blood taken from the heart. Where cases have died in an atmosphere of carbon monoxide, or shortly after being removed therefrom, the blood resists decomposition for a considerable time, and the spectroscopic examination may be of value even after the lapse of two or three months. Such blood also keeps its bright red color. A note on the color and condition of preservation of blood that is taken for examination is of importance, since with decomposition (especially if ammonia is present in abundance) hæmatin is formed. Such blood is of dark color and becomes cloudy when mixed with water. The absorption bands are not clear, or there is only a shading in the green. On addition of ammonium sulphide two bands appear—*i.e.*, the spectrum of reduced hæmatin.

The differential diagnosis between illuminating-gas and coal-gas poisoning may not be easy to make. Cases of poisoning by illuminating gas present the most characteristic appearances post mortem and on spectroscopic analysis; those of poisoning by coal gas, from the larger percentage of carbon dioxide, present less characteristic appearances, and the spectroscope may show the bands at D and E, after the addition of ammonium sulphide, together with a more or less deep intervening band between them. In cases of death in conflagrations the effect of inhalation of smoke, as shown by the presence of black, sooty deposits upon the respiratory mucosa, is quite characteristic.

Besides spectroscopic analysis there are a number of chemical tests, very easy of application at the autopsy table, which prove of aid in doubtful cases. The addition of a drop or two of a ten-per-cent. sodium hydrate solution changes the color of other blood to a dirty brown or brownish green; carbon monoxide blood remains bright red. Solution of a copper salt changes the color of other blood to chocolate brown; carbon monoxide blood remains red. Tannin, ferrocyanide of potassium, and acetate of lead form a brown precipitate with other blood, a red one with carbon monoxide blood.

These tests, and also the spectroscopic test, may produce recognizable results in some cases in which death has occurred even sixty hours after exposure to carbon monoxide; in other cases, however, the reaction can barely be made out even when the interval amounts to only two hours.

A certain number of lesions which sometimes occur subsequently to carbon monoxide poisoning may aid in reaching a diagnosis where from the length of time between cessation of exposure and death the above tests fail. Croupous inflammation of the fauces has been noted where death followed seventeen hours after coal-gas inhalation. In some cases there are vaso-motor and trophic disturbances of the skin which predispose to necrosis from pressure. A case with dermatitis bullosa on both hands has been reported, death taking place five days after exposure to coal gas. In another case death occurred at the end of eight days. Symmetrical softening of the anterior part of the inner capsule and adjoining portion of the head of the caudate nucleus, also of the inner part of the lenticular nucleus, has occurred in a number of cases in which a day or more has intervened. Its occurrence has been explained by Kolisko on the ground of the peculiar course of the arterial branch (the long anterior perforating branch of the anterior cerebral) which supplies the part, its course being in the reverse direction to that of the artery from which it springs, so that with the decrease of pressure, which is the result of carbon monoxide poisoning, a diminution in the flow of blood or even stasis may occur.

Hydrocyanic acid.—This acid, alone, produces merely injection and ecchymoses of the mucosa of the stomach, which may in part be explained by the condition of asphyxia, death occurring rapidly therefrom. Besides the odor of bitter almonds there is nothing characteristic.

Cyanide of Potassium.—The mucosa of the stomach over its entire surface or at the fundus, or especially upon the crests of the folds, is deep red in color, swollen and softened, and presents sometimes almost a translucent appearance; a thick mucus, which is tinged a light red

or brownish red from blood, covers the surface. The stomach contents are usually blood tinged and stringy. The reaction is strongly alkaline. The mucosa is soapy or slippery to the touch. The characteristic odor of bitter almonds is present in the stomach, and also in other organs, as the brain and lungs. The odor of ammonia may be distinguished either from its presence in the cyanide, or through the effects of decomposition in the stomach. The redness and swelling of the mucous membrane are due to injection and ecchymoses, the primary effect of irritation, and to the secondary action of solution of the albuminous constituents of the tissue and imbibition of the superficial layers with hæmatin due to the strong alkaline action. The secondary effect, therefore, may be absent or poorly marked when the dose is small or when its effects have been counteracted by the acid contents of the stomach. In such cases, unless a characteristic odor is present, the diagnosis can be made only by chemical examination.

The same effects may be apparent in the mucosa of the duodenum, pharynx, œsophagus, larynx, trachea and bronchi, especially if, during vomiting, some of the potassium cyanide has been aspirated. In some cases the crests of the folds in the mucous membrane of the stomach may present a grayish-white appearance.

The blood usually presents the condition found in asphyxia, *i.e.*, dark and fluid. The spectrum is identical with that of oxyhæmoglobin and is reduced by ammonium sulphide. Occasionally it is light red. This color may be due, according to Hoffmann, to the hyperalkalinity of the blood, which is easily and quickly produced by the ammonia contained in cyanide of potassium, more especially in old samples. Traces of ammonia cause the appearance of a light red color in blood solution, and clarify turbid solutions. Others ascribe the light red color to the formation of a compound of cyanogen with methæmoglobin or hæmatin. If to a dilute solution of normal blood ferricyanide of potassium be added, there is an immediate change in color from red to brown, and in the spectroscope a methæmoglobin band appears between C and D. A trace of hydrocyanic acid or of cyanide of potassium will change the solution to a red color, and in the spectroscope there will appear in the green a broad band which, after the addition of ammonium sulphide, changes to two bands.

Nitrobenzol Poisoning.—The mucosa of the stomach and small intestine is injected and ecchymotic. The odor of bitter almonds in the stomach, brain, and lungs is even more marked and persistent than in hydrocyanic acid poisoning. The blood and muscle are brownish in color. From the presence of brownish methæmoglobin in the uriniferous tubules, especially in the pyramids, a resemblance to chlorate of potassium poisoning is produced.

Arsenic.—Arsenious acid usually does not produce corrosive effects upon the mucosa. These effects, although they have been observed in several cases, are evidently of rare occurrence. This poison, however, does produce an intense gastro-enteritis. There is nothing characteristic about the external appearance of the cadaver, or about the condition of the mouth, pharynx, or œsophagus. The mucosa of the stomach is intensely congested throughout or in patches; it is œdematous, swollen, and sometimes ecchymotic. It is covered with blood-tinged mucus, and scattered over its surface may be found granules or crystals of arsenious acid. These are sometimes large enough to be felt or even to be seen. The small intestine is filled with thin fluid, almost watery, with flocculi—the characteristic rice-water contents. The mucosa is congested, markedly swollen, œdematous, and flaccid. In the lower portion of the small intestine and in the large intestine, the mucosa may be pale. There is marked parenchymatous or fatty degeneration of the glands of the stomach and intestine, of the epithelial cells of the kidney and liver, and of the heart muscle. In some cases the stomach may present few or no changes, but the changes in the intestine are far more constant.

The appearance of yellowish streaks occasionally seen on the stomach mucosa are due to the formation of yellow sulphide of arsenic.

The colon may be covered with thick mucus containing desquamated epithelial cells and many lymphocytes. There may be a croupous colitis. The mesenteric lymph nodes may be swollen. There may be ecchymoses in the pericardium and pleura, but especially under the endocardium. The blood is usually poorly coagulated, and in the peripheral vessels may be thick and tarry, due to loss of water. In some cases there is slight jaundice, and ecchymoses may appear in the faucial mucous membrane and in the cellular tissue of the neck, but not in the muscle. When ecchymoses appear in the pleura and mediastinum, and fatty degeneration of the heart, liver, and kidney is present, the case may resemble phosphorus poisoning. The hemorrhagic spots in the mucosa of the stomach may become eroded by the gastric contents, and this doubtless explains why a corrosive action is ascribed to arsenic, which it most probably does not possess.

Arsenic is more rapidly eliminated than other metallic poisons, and it is conceivable that death may occur from arsenic poisoning and yet quite small amounts of arsenic be found. It is therefore of importance to preserve for examination in suspected cases not only the stomach and intestine and their contents separately, but also the heart, kidney, liver, bone, and muscle, since in some cases arsenic has been demonstrated in these organs, more especially in the liver and bone, when its demonstration has failed in the stomach and intestine or in their contents, by reason of its having been already eliminated. Much of the arsenic that has been taken internally may have been gotten rid of by vomiting and diarrhœa, common with arsenic poisoning. In cases in which examination is made after burial it is important not only to take portions of every organ and tissue of the body, inasmuch as it is well known that arsenic may diffuse itself through the tissues post mortem, but also to take samples of the objects surrounding the cadaver, including wood of the casket and surrounding earth. In addition to this it is also of importance to take another sample of earth from another part of the cemetery. All organs should be carefully weighed at the time of the autopsy, and if possible the entire organ should be given to the chemist. If this cannot be done, provided the weights of the organs are known, a basis for calculation of the amount of arsenic is furnished. It is both affirmed and denied that the cadaver after arsenic poisoning resists decomposition for a considerable length of time. Mummification has been described as a characteristic appearance. This may, however, be due to other conditions, such as burial in sandy soil, et cetera.

Aceto-Arsenite of Copper, Paris Green.—The appearance of this substance, its characteristic color, its insolubility, and the fact that it appears in the stomach in pasty masses, loosely adherent to the mucosa, which is swollen, œdematous, congested, and ecchymotic beneath the attached mass, renders the diagnosis of this form of poisoning quite easy. The small intestine shows the same appearance as in poisoning by arsenious acid. The Paris green may be covered by a brownish magma, the reduced iron given as an antidote.

Phosphorus.—Red phosphorus is not poisonous; the yellow variety is intensely so. Acute cases (death in from four to eight hours) may show but few pathological changes. The contents of the stomach and intestines may smell of phosphorus and may shine in the dark on being shaken; pieces of matches may be found. The gastric mucosa, heart muscle, and epithelial cells of liver and kidney may show cloudy swelling. The subacute cases (death after from three to seven days) commonly show characteristic changes. The stomach is not corroded, ecchymoses and hemorrhagic erosions are common; the gland cells, especially the adelomorphous cells, are in marked fatty degeneration, so that the ducts are marked by yellowish points (gastradenitis phosphorica). The contents may be dark brown from the presence of blood. Phosphorus may no longer be demonstrated chemically in the stomach and its contents, in the sub-

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acute cases. The lower part of the small intestine and the colon are more likely to contain phosphorus. Jaundice is regularly present and marked. Ecchymoses, which are a characteristic lesion in poisoning by phosphorus, are abundantly present in the gastric and intestinal mucosa, in all the serous membranes, especially the pleura and the pericardium, in the adventitia of the aorta and its branches, in the conjunctiva, in the subcutaneous areolar tissue, in the intermuscular tissue, and in the mediastinum. Hemorrhages may occur from the stomach and intestine, and from the uterus, in some cases causing death. The blood is fluid in acute cases, poorly coagulated in subacute cases. The red cells are disintegrated, the white cells may be fatty. Fatty degeneration of the liver, kidney, muscle of the heart, and arteries is very well marked. The organs are bile-stained and the fecal masses in the lower part of the small intestine and colon are grayish. The jaundice, excessive fatty degeneration, and hemorrhagic changes are so well marked that the diagnosis usually presents no difficulty.

Acute yellow atrophy of the liver, and septicæmia with jaundice, ecchymoses, and fatty degeneration of the viscera, may closely resemble phosphorus poisoning; this being specially true of the former. In acute yellow atrophy, although a primary enlargement of the liver may take place, the characteristic conditions are: marked diminution in size and consistency, the occurrence of reddish softened areas where the epithelial cells are disintegrated into a granular detritus, and the appearance of round-celled infiltration of the connective tissue. Many bacteria have also been observed in this form of poisoning. The liver in phosphorus poisoning is usually large, and although of doughy consistency, it is still firmer than in acute yellow atrophy. Punctate hemorrhages may be present, but the reddish areas described above are absent. In septicæmia with jaundice and ecchymoses, the fatty degeneration is usually not so far advanced as in phosphorus poisoning. The resemblance may, however, be so close as to render a decision, simply from the gross appearances, impossible, in which case the demonstration of phosphorus by chemical examination, or the demonstration of bacteria by bacteriological examination, will clear up the diagnosis.

Bichloride of Mercury Poisoning.—In the acute cases, in which death occurs in collapse after a few hours, the corrosive effect upon the mucosa of the mouth, pharynx, œsophagus, and especially the stomach, is apparent in the presence of grayish-white eschars. From the action of mercury upon the blood the eschar may show a grayish-violet tinge. In cases that have survived a few days the eschar may in part have been cast off, presenting ulcers with undermined edges, the submucous tissue being congested and ecchymotic. Where the action has not been sufficiently strong to cause corrosion, the mucosa may be congested and ecchymotic. The upper portion of the small intestine may also show the same effects, which gradually become less marked as we advance downward from the stomach in the course of our examination. In subacute cases, these portions of the alimentary tract may show no changes or merely those of a diphtheritic inflammation. In the lower portion of the ileum and in the large intestine, the characteristic changes are found, consisting of an inflammation of an acute exudative type with necrosis and the formation of a membrane, affecting more especially the crests of the folds and the areas in and about the lymphadenoid tissue. The submucosa is considerably distended with serum and infiltrated with pus cells. The gross appearances closely resemble those of dysentery. This effect is not due to the local action of sublimate; it seems to be due to the excretion of the poison, especially by the large intestine, since it is equally well marked in cases of mercury poisoning by inunction, by subcutaneous injection, and by intra-uterine injection. The kidneys are enlarged, soft, and œdematous. The cortex is markedly swollen, and of a light yellow or grayish color. The pyramids are dark and congested. These changes are due to parenchymatous or fatty degeneration of the epithelium of the uriniferous tubules, especially in the cortex, and to an acute exudative inflammation. A marked proliferation and desquamation of epithelium may occur. The stroma of the kidney is infiltrated with serum.

Potassium Chlorate.—The oxyhæmoglobin is reduced to methæmoglobin, and in addition the red blood cells are disintegrated. The blood presents the appearance of thick chocolate or coffee grounds. The post-mortem spots are grayish or grayish violet. Jaundice may be present. The spleen may be enlarged. The kidneys present a characteristic appearance. An acute exudative nephritis of hemorrhagic type is invariably present. It is characterized by especially well-marked changes about the glomeruli, the uriniferous tubules being filled with brown blood clots which give the appearance of brownish striations more marked in the pyramids.

Opium and Morphine.—If opium has been taken in substance or in tincture, the characteristic odor may be present, and if in the form of tr. opii crocata, a characteristic yellow color may be distinguishable. If a decoction of poppy heads has been taken, particles of the plant may be discovered and identified by the microscope. As far as the appearances post mortem are concerned, there is nothing characteristic upon which the diagnosis can be made positively. Passive hyperæmia of the brain and lungs may be found. The blood in acute cases is usually fluid, in others it is clotted. The appearance of the pupils is of minor importance, since the marked contraction may not be preserved post mortem.

Strychnine.—Early, intense, and persistent rigor mortis has been noted, but this occurs in other conditions. The blood is dark and fluid (asphyxia); passive hyperæmia of the brain and lungs and ecchymotic spots may be present.

Atropine and its group, digitalis, veratrine, aconite, aloes, colocynth, jalap, scammony, savin, croton oil, colchicum, hellebore, elaterium, may all produce the effects of gastro-intestinal irritation, depending upon the amount of the drug—namely, hyperæmia, ecchymoses, intense catarrhal or sometimes croupous inflammation, or even necrosis.

Ptomaïn Poisoning.—The appearance post mortem is not characteristic; a more or less intense gastro-enteritis may be the only lesion found. In addition, parenchymatous degeneration of the liver, kidney, and heart muscle, general passive hyperæmia, ecchymoses, and dark fluid blood may be present.

Muscarine Poisoning (toadstools).—Cases have been described with jaundice, ecchymoses in the cutis, acute fatty degeneration of the liver, kidney, and heart muscle. The remains of toadstools in the gastro-intestinal tract and their botanical determination may lead to the diagnosis.

Chloroform.—Death from narcosis may leave no characteristic signs except those of asphyxia. The odor of chloroform may be present or absent in the lungs, stomach, and brain. In some cases, the presence of chloroform may be demonstrated in the blood or in the brain by chemical examination. If swallowed, the odor of chloroform may be apparent in the stomach contents, and the mucosa of the stomach may present a soft grayish slough where the chloroform has come in contact. In one case in which death from pneumonia occurred five days after swallowing chloroform, extensive ulceration of the stomach and jejunum was found; and similar lesions were observed in another case in which death occurred after twenty-seven hours. The blood is fluid or poorly clotted according to the rapidity or slowness with which death has set in. Decomposition after chloroform poisoning takes place rapidly, and there will be gas bubbles in the blood—a certain indication, as was formerly believed, of chloroform poisoning. In cases dying some time after chloroform narcosis, parenchymatous degeneration of the heart, liver, and kidney has been found.

Chloral hydrate may simply produce a marked hyperæmia of the lungs, brain, and spinal cord. It is important to take a specimen of the urine for chemical examination.

Ether.—Poisoning from ether narcosis may simply show the signs of asphyxia, viz., fluid and dark-colored

blood and the occasional presence of ecchymoses. In recent cases the odor of ether may be detected in the lungs, stomach, and brain. Poisoning from ingestion of ether produces the effects of intense gastro-intestinal irritation.

It is of interest, and also of medico-legal importance, to examine the lymphadenoid tissue throughout the body—namely, the naso-pharynx, tonsils, dorsum of the tongue posteriorly, solitary follicles of the stomach and small and large intestine, Peyer's plaques of the small intestine, the mesenteric and retroperitoneal lymph nodes, the Malpighian bodies of the spleen, and the thymus gland. A hyperplasia of these structures—termed status lymphaticus—predisposes to the occurrence of sudden death from causes that otherwise appear insufficient. In a number of cases of death following chloroform and ether narcosis this condition has been found. In some of these cases very small amounts of ether and chloroform had been given and had been very carefully administered.

Alcohol.—Concentrated alcohol coagulates albumin and extracts water, and may therefore produce a direct corrosive action upon the gastro-intestinal mucosa. Numerous cases of sudden death following ingestion of large amounts have occurred in adults, and comparatively small amounts have sufficed to cause death in children. Post mortem there will be found the signs of asphyxia, with alcoholic odor from stomach contents, lungs, and brain, and with intense gastro-enteritis. It is stated that in chronic alcoholics intolerance of alcohol increases with the advancement of the chronic pathological changes due to its long-continued use, so that comparatively small amounts may finally cause death.

Glass, if finely pulverized, is not poisonous, as is commonly believed by the laity. If, however, the particles are larger, an intense irritant effect on the mucosa of the stomach and intestines may be mechanically produced, and cases of death from this cause are on record.

Trichinosis.—As deaths occasionally occur from an invasion of trichina spiralis, due to the ingestion of "measly" pork, the vender of such meat or sausage might be held responsible. In such a case the contents of the stomach and upper portion of the intestinal tract should be examined for free trichinæ, and the muscular tissue, especially of the diaphragm, chest, and neck, for encapsulated trichinæ. At the same time due consideration must be given to the history of the case, and to such other points as may throw light upon the source of the infection.

Anthrax.—Intestinal anthrax has occurred in a number of cases in which an invasion of the bacillus has been directly traced to infected meat. In some cases the meat had been thoroughly cooked. This is not surprising in view of the resistance of anthrax spores to high temperatures.

Mortal Injuries.—The medico-legal questions that arise are the following:

1. Differentiation between post-mortem changes and the effects of injury.
2. Differentiation between injuries inflicted before death and post-mortem injuries.
3. The determination of the immediate cause of death, whether directly due to the injury, and, in the presence of more than one injury, the determination of which one immediately caused death, or whether more than one injury was necessarily fatal.
4. The determination, if possible, of the character of the injury, and of the means and method of its infliction; also whether the means and method alleged, and the circumstances reported as having attended the act, are compatible with the character of the injury.
5. Whether the conditions found are compatible or not with suicide, and, in the case of more than one fatal injury, whether or not the injuries might have been self-inflicted.
6. The determination of the cause of death where disease follows injury, and also the determination of the question whether the disease is the direct result of the injury or not. When an injury occurs in a subject already diseased, it is important to learn whether or not the diseased condition might have predisposed to the occurrence of the accident in which injury was sustained, or whether the outcome of the injury was influenced for the worse by reason of such pre-existing disease.

1. After death the blood remaining fluid in the veins and capillaries naturally flows to the most dependent portion of the cadaver, collecting especially where the skin is not subjected to pressure. With the occurrence of decomposition the red blood cells disintegrate, and the serum tinged with blood-coloring matter may transude through the vessel wall and infiltrate the surrounding loose areolar tissue. Therefore the early post-mortem spots may be entirely obliterated by pressure. When, however, post mortem transudation has occurred the spots are permanent. When decomposition is advanced the cutis, subcutaneous tissue, fascia, and even the muscle may be markedly infiltrated and succulent. Under these conditions ordinary post-mortem changes, unless their character and the fact of decomposition having taken place are noted, may be mistaken for contusions, ecchymoses, or hæmatomata. Indeed, it is found that after death, even without the presence of injuries, when the veins and capillaries are distended with blood from the parts being in a dependent position, minute lacerations may occur and thus give rise to the formation of ecchymoses. Such have been found, for instance, in the conjunctiva on one side when the head has been lying on that side, and in the skin of the lower extremities when death has occurred by hanging, the cadaver having been suspended for some days. Where, however, such effusion of blood does occur its extent is not usually equal to that following actual contusion or that due to the formation of a hæmatoma during life. When a contusion occurs or a hematoma develops during life the effused blood usually clots; if, however, decomposition is far advanced, the clot may be partially disintegrated and some difficulty may be experienced in determining the exact condition of things. If we take into consideration all the above points, and the fact that it is just this formation of clot that hinders the further transudation into the tissues, a conclusion can generally be reached.

2. Besides obvious mutilations of the cadaver, embracing wounds, fractures, and lacerations of tissue, post-mortem injuries may be unknowingly produced during the performance of an autopsy. A wound sustained during life, however, will present certain easily distinguishable characters. There will be some inflammatory reaction about the wound, or granulation tissue will be present, or the edges of the wound will have become adherent. The effusion of blood in the tissues about the wound, especially the clotting of blood in these tissues, forms additional evidence. Evidence of hemorrhage internally or externally is in favor of injuries sustained during life. It is possible, however, for blood to flow from a wound made after death if the wound has been made in a dependent portion of the body, if a large vein has been opened, or if decomposition is somewhat advanced. Gaping of the wound where the subcutaneous areolar tissue is loose favors the idea that the injury was sustained during life. Where, however, the skin is thick and the subcutaneous tissue denser and more adherent, gaping may not occur. Gaping of the wound or eversion of its edges may occur when subcutaneous fat is present in considerable amount, and when decomposition has taken place. The sign, therefore, is not an absolutely reliable one for or against, but may be of value if these restrictions are taken into account. Fractures may occur post mortem and may be unknowingly produced, during the autopsy, especially in senile cases of osteoporosis, by overextension of the cervical vertebræ. The absence of hemorrhage and of inflammatory reaction readily excludes the possibility of a fracture having occurred during life. By the same manipulation transverse laceration of the sterno-cleido-mastoid muscles may be produced. In deciding the question of post-mortem occurrence or of infliction during life the same restrictions hold as were discussed above.

Injuries may occur just before death in cases of sudden death from disease or in cases of poisoning, as the result of a fall. These may evidently be of slight importance. In cases of cerebral hemorrhage of this type it may be of considerable importance to determine whether or not such hemorrhages are of this character and have followed some primary lesion.

3. An injury may be sufficient of itself—if it should seriously damage or destroy some vital organ—to cause death. There are cases, however, in which the decision that a given injury must necessarily have been fatal is very hard to reach. This is due to the fact that in rare cases the patient will recover from injuries which are commonly looked upon as necessarily fatal. Then again, even if he does not recover, he may live for days or weeks after the infliction of the injury.

Secondary mechanical effects following the injury may be the immediate cause of death. Among these may be mentioned compression of the brain by blood clot, interference with heart action by hemorrhage into the pericardial sac, pneumothorax from a penetrating wound of the chest wall or also of the lung itself, and laceration of the lung by a fractured rib.

Hemorrhage, external or internal into one or another body cavity, may be the immediate cause of death. If it is internal, the actual amount of blood lost to the circulation may be directly measured; if it is external, and the evidence of the autopsy alone is at hand, we must depend for our diagnosis upon the anæmia of the organs. If death is due to hemorrhage, all the organs are pale and almost bloodless; the heart and vessels contain much less blood than normally and are contracted. This applies, of course, to cases in which death immediately follows the loss of blood. If some time has intervened between the occurrence of the hemorrhage and death, there will be an anæmic condition, an hydræmia; but the organs will not be found in the bloodless, dry condition characteristic of those cases in which death follows immediately after hemorrhage.

The immediate cause of death may be shock. There is no positive evidence post mortem upon which such a diagnosis could be based independently of the history of the case. Multiplicity of injuries, extent of injury, evidence of compression or contusion of the abdomen as afforded by marked dilatation of the abdominal veins, might all favor such a conclusion. The clinical history, especially the time intervening between injury and death, taken in connection with the above data, is probably better evidence. In this connection it should be remembered that there are undoubted cases of death from shock alone without the infliction of injury. In many, of course, a neurotic predisposition may be presumed, or the existence of heart lesions or disease of the cerebral vessels may explain the cause of death, the shock in such cases producing a nervous or vascular effect determining the occurrence of syncope and death.

In the presence of more than one injury, the effects of each should be carefully weighed and its importance in the causation of death determined. Each injury should be separately considered and the probable result, if such injury alone were present, determined. This is a matter of considerable importance, as the injuries may have been inflicted by different individuals, or by the same individual under different circumstances; as, for instance, when a first shot is fired in self-defence and a second when the assailant has turned in flight. The question might arise whether one of the wounds might have been self-inflicted, the other having been admittedly inflicted by the defendant on trial. Such might possibly be the case in a struggle, both the participants being armed, or where an officer in pursuit of a fugitive, revolver in hand, is afterward found dead with two bullet wounds. Even though there may be evidence of his weapon having been recently discharged, this of course would not be conclusive of one wound having been self-inflicted.

4. An accurate description of all injuries, their character, location, tissues involved, measurements, direction, and external appearance, including that of surrounding parts, not only of the body but also of the clothing if possible, should be made in every case. This is of the greatest importance, and may be the only admissible evidence upon which a case can be decided by the jury.

A contusion according to its severity indicates more or less forcible contact with some flat or blunt firm substance—*i.e.*, either a blow or a fall. Which is the case in a given instance may be impossible to decide from the contusion alone. Its size may afford some help; its location may be of more importance. Such situations compatible with a fall will readily suggest themselves, yet many of these contusions may not be distinguishable from those which are the result of a blow. If, however, the area of contusion is smaller than the area which might readily have come in contact with given surrounding objects, the conclusion would be in favor of a blow.

Abrasions favor the conclusion of a glancing fall or blow.

A hæmatoma may occupy the site of contact in a blow or fall, or may be secondary to a fracture the result of such blow or fall, and may occupy a position near or at a distance from the immediate site of contact.

Wounds are described as incised, contused, lacerated, and punctured. These adjectives readily suggest a cut or a thrust with a sharp, blunt, ragged, or pointed instrument; or a fall upon such sharp, blunt, ragged, or pointed object. It should be remembered, however, that the appearance of an incised wound may be simulated when such wound occurs over projecting bony ridges, as the supraorbital ridge, nose, margin of jaw, tibia, et cetera, although really produced by blunt objects either from a blow or from a fall. Even a bullet wound may occasionally resemble an incised or punctured wound from the splitting of the skin over a bony surface.

Bullet Wounds.—The accurate description of their special characteristics is of the greatest importance, not only in proving the presence of a bullet wound when the bullet cannot be found, but also in furnishing data from which valuable conclusions may be drawn. The points for examination and description are as follows:

(*a*) The skin and surrounding parts externally.

(1) The solution of continuity in the skin.

(2) The immediate surrounding narrow zone of contusion, abrasion, and lead staining. Both of these are effects produced by the bullet.

(3) The stain or smudge which can readily be wiped off or washed off, the effect of the smoke.

(4) The embedded powder particles, some of which from their very superficial location can be washed off, while others more deeply situated remain—the effect of incomplete combustion of the powder.

(5) Burning of the surrounding skin and singeing of the hair, the effect of the flame.

(6) The zone of contusion about the wound larger than that produced by the bullet—the effect of concussion of the explosive gases.

(*b*) Immediately beneath the wound in the skin the following effects may be noted:

(1) Contusion and laceration of tissue by the explosive gases.

(2) Staining by smoke and by particles of powder unchanged or incompletely burned.

(3) Burning or charring by the flame, ignited powder, or wad.

(*c*) The track of the bullet and the tissue surrounding it may present the above effects of laceration from the explosive gases, charring from the flame, and blackening from embedded particles of powder; and in soft parts these effects may be even more marked than directly beneath the skin on account of the centrifugal distribution of these effects. In bullet wounds of the brain still other effects may be produced; some of them being due to the fact that smaller or larger fragments of bone are carried in like projectiles, and others resulting from the fragmentation of the bullet, the result either of the composition of the metal or of the manner in which the bullet has struck the bone.

If we take these facts into account, it can readily be un-

derstood how these effects vary according to the size, calibre, length, shape, consistence, and structure of the bullet; the kind, condition, and amount of the powder charge; the character of the weapon, whether a rifle, gun, pistol, or revolver; and the range from which the shot was fired. Intervening clothing and hair, depending upon its amount, texture, and arrangement, may influence certain of these appearances, causing their absence in the wound or upon the skin when otherwise they would certainly have been present.

From experiments performed upon the cadaver with different weapons of different calibre, at ranges varying from contact onward, and upon different parts, results have been produced which with certain minor limitations form a basis upon which, when the effects produced in a wound are known and the circumstances set forth above are taken into account, the range at which the shot was fired can be determined with considerable accuracy. It is not meant that the distance can always be determined within an inch; nor is such determination always called for. We can determine, however, that certain effects could not have been produced beyond a certain range, or within a certain range, and thereby we shall be able to exclude suicide or to admit its possibility. The effects produced in the wound may then be the only evidence upon which a decision can be reached, or may prove strong corroborative evidence, or may be the only means of preventing an unjust conviction.

The wound in the skin may be round, its edges roughened by contusion; or, by reason of small lacerations of its margin, it may present the appearance of a rosette. Again, it may be quite large and may have a triangular or ovoid shape; or it may be slit-like and resemble an incised wound, the bullet having caused a splitting of the skin. Such a wound may heal by primary union and obscure the character of the injury. It is produced more frequently with revolvers of smaller calibre and by pointed bullets. Aberrations from the circular or round form of wound may be produced by the bullet striking the skin surface at a more acute angle. Larger lacerations leading from the wound may in some cases be explained by the effect of the explosive gases beneath the skin. (For further details in regard to the different characteristics of bullet wounds the reader is referred to the article on *Gunshot Injuries* in a later volume.)

The limit of the range beyond which grains of powder cannot become embedded in the skin adjacent to the wound varies, according to the calibre of the weapon used and the amount of the charge of powder, from about one foot with a small revolver to three feet and more with those of large calibre, six feet with the old-style army pistol, and a still greater distance with a shot-gun. Embedded powder grains are found within these ranges for weapons cited. They are few in number and scattered with the higher range, and more concentrated and abundant as contact is approached, on account of their centrifugal distribution. With contact they are usually absent in the skin but present in larger amount in the tissues beneath, the depth depending upon the calibre of the weapon and the amount of powder in the charge. With a revolver of medium calibre the deposit of powder grains in the wound diminishes with increase of range to mere staining of the bullet track, so that beyond one inch the effect of powder grains in the wound ceases to be observed. When the muzzle is not held in immediate contact the powder grains appear in the skin about the wound, and the appearance varies with the distance as stated above.

At contact the effect of the explosive gases and the staining and charring of the subcutaneous wound are most marked, varying according to calibre and powder charge. Laceration of tissue thus produced is almost constant with 0.32 to 0.44 calibre, but is exceptional with 0.22.

Burning of the hair is more extensive than burning of the skin, and varies according to the calibre and the range. With an 0.22 calibre it varies from contact to three inches; with an 0.44 calibre, from contact to fifteen inches. At contact there may be no singeing of the hair at all, or if present it is confined to a few hairs immediately about the wound. With a revolver of medium calibre, at one-quarter of an inch, singeing is invariably present but may be limited to an area of one inch or less. At a range of from three to five inches singeing is no longer constant.

Burning of the skin varies in the same way and within narrower limits. At contact, with a revolver of medium calibre, there may be charring of the edge of the wound, but the greatest effect is produced on the underlying tissues. At a distance of from one-quarter of an inch to three inches charring is usual but not constant; at greater ranges it is absent. With larger weapons it may occur at greater ranges.

To recapitulate, the effects will disappear in the following order, as the range is increased from contact to the maximum limit:

(1) Effect of explosive gases.
(2) Effect of smoke stain or smudge which can be wiped or washed off.
(3) Effect of the flame in burning of the skin.
(4) Singeing of the hair.
(5) Embedded powder grains.

Protection of the part by clothing or hair will explain the absence of some effects, namely, smoke stain, embedded powder grains in the skin, or burning of the skin at short range. In such cases we may have the valuable sign of singeing of the hair to guide us.

The track of the bullet, besides presenting effects already noted, may be of importance in establishing the direction from which a shot was fired or the position of the body when the shot was fired. Care should be taken in reaching conclusions, since it is well known that the course of a bullet may be deflected especially by bone, and that a bullet may wander not only after being in the body a considerable time, but also in fresh cases. The track is of importance also as a guide to the location of a bullet. The track may contain the wad, and in an interesting case in literature such a wad served to convict. A gamekeeper was found dead in the forest; the wad was not burned and proved to be part of a calendar in possession of a notorious poacher.

Although the bullet may be markedly deformed or flattened, the rim at its base is usually sufficiently intact to determine its calibre. Certain markings upon the bullet may prove valuable evidence of its having been fired from a given weapon. Moreover, its presentation to the jury is the best evidence that the wound was really produced by a bullet.

Multiple wounds may be caused by the same bullet passing through the upper extremity and thorax, or lower extremity and abdomen, or through mamma and thorax; three or more wounds being present in the skin. It is necessary to distinguish wounds of entrance from wounds of exit. As far as the soft parts are concerned, this has been discussed above. In the calvaria the fracture produced is an excellent criterion. The table upon which the bullet impinges first is fractured to a less extent. Thus, in wounds of entrance the outer table presents the smaller opening, the inner the larger opening; the fracture shelves inward. In wounds of exit the inner table presents the smaller opening; the fracture shelves outward.

The opening made by the bullet in passing through bone is usually larger than the calibre of the bullet, and in the case of bullet wounds of the brain the canal of the bullet may also be considerably larger, this effect being due in part to the flattening of the bullet against the bone, and in part to the carrying in of fragments of bone.

Where deflection has occurred and where, as in the abdominal cavity, the bullet may traverse a considerable distance without causing lesions, the track or canal of the bullet may not lead directly to the bullet itself. In one case the wound of entrance was located in the right hypochondriac region and with it was associated a wound of the transverse colon and its mesentery. The direction of the track, up to this point, was backward, inward, and slightly downward, yet the bullet was found em-

bedded beneath the ilio-psoas muscle on the left side of the fifth lumbar vertebra. In another case the wound of entrance was located on the anterior and inner aspect of the left thigh, with perforation into the peritoneal cavity below Poupart's ligament. The bullet, however, was found in the stomach, and there was a wound in its posterior wall near the greater curvature, with a second wound in the transverse mesocolon. In bullet wounds of the brain the amount of deflection may be considerable, so that the canal may pass through the superficial part of the cortex, from one side of the calvaria to the other. The angle of deflection may be very acute. Thus in one case the wound of entrance was located over the left parietal boss, while the track passed downward and across the median line through the brain to the right side of the frontal bone, causing comminution at the junction of the orbital plate and perpendicular portion. A second canal was found in the right hemisphere leading to the bullet; the latter being very much flattened beneath the right parietal boss, which was excessively comminuted.

The discharge of a weapon at contact, provided the powder charge is sufficiently large, even though there is no bullet and consequently no bullet wound through the skin, may cause death. A case is reported of laceration of the heart through such a discharge at contact against the præcordial region. The skin presented the usual appearances with the exception of a bullet wound, *i.e.*, smoke stain, burn, and embedded powder grains were visible.

Cases have occurred in which the mouth was filled with powder, which was then ignited.

The extent of comminution of bone varies with the character of the bullet, its soft or hard consistency, its structure, its calibre, powder charge, and range; in addition the thickness of bone must be taken into account.

5. The decision whether a bullet wound was self-inflicted may be difficult to reach when the wound presents the appearance of a shot at contact, or within a range at which self-infliction is possible. Such wounds may of course have been inflicted by another individual. The wound in suicide, although usually inflicted at or nearly at contact, need not of course have been so inflicted. From the situation of the wound of entrance, and the direction of the track, valuable conclusions may be drawn; but the possibility of suicide should not be excluded except after the most careful consideration, since peculiar methods of handling the pistol may have been employed, such as steadying the barrel with one hand against the part and pulling the trigger with the other. From the reflection of smoke and powder grains the hand may become stained. Careful examination of both hands with this end in view should be made, and from the above it can easily be understood how the stain may appear, not only upon the hand used to discharge the weapon, but where the barrel has been steadied with the other hand this may be stained, and yet the stain be absent upon the hand that has pulled the trigger. This will explain, for instance, the presence of a bullet wound on the right side of the head, and a powder stain on the left hand. The palm and flexor aspect of the thumb should be examined for scratches or contusions that might have been produced by the recoil of the revolver. All attending circumstances should be noted. Of course, the revolver still grasped in the hand of the deceased does not necessarily prove suicide, as it is conceivable that before rigor mortis has set in such a condition may be directly produced post mortem.

The question of multiple self-inflicted wounds comes up for decision in cases in which one or more were necessarily fatal, and it may be important to decide whether one was immediately fatal. The presumption may arise that the second wound could not have been inflicted after the infliction of the first. Double bullet wounds in the heart have been self-inflicted. Whether a bullet wound of the brain necessarily prevents a further voluntary action, is often hard to decide. Of course, if a vital centre has been lacerated death must have occurred immediately thereafter. Still it is quite possible that laceration of the brain, and sometimes quite considerable laceration, may occur in uncommon cases without being immediately fatal.

Bullet wounds and other injuries may occur in cases of suicide, all having been self-inflicted. In addition, numerous cases have been reported of poisoning and traumatism in the same individual.

6. The estimation of the relative importance of disease and injury and of their dependence upon each other is best considered regionally. Certain considerations apply in all cases. Thus, for example, it must be remembered that a wound infection—such as septicæmia, pyæmia, erysipelas, and tetanus—may follow an injury. Local tuberculous processes may be secondary to traumatism. Pneumonia may follow an injury and may prove fatal. When injuries occur in a subject of chronic disease, the injury and the disease should be separately considered, and the attempt should be made to determine the part played by each in the causation of death. Post mortem, the differentiation between the results of disease and those of traumatism should be made, and in this connection the subject of hemorrhage is important, as it may be the result of either. Mistakes may be made in determining the origin of hemorrhage.

HEAD.—*Concussion of the Brain.*—External signs of violence may be present, but cases may occur of even fatal concussion with little or no evidence of external violence. The brain is usually congested, and sometimes shows multiple and very fine contusions over the entire surface. The floor of the fourth ventricle is a spot where important evidence may be found in these cases, and it should be examined from above, the brain having been laid on its base with the cerebellum toward the observer. After section of the cerebral hemisphere on either side, a median incision is made through the cerebellum until the ventricle is reached. Then the incision is to be extended anteriorly to the corpora quadrigemina and posteriorly to the divergence of the restiform bodies. Finally, the separation of the two halves of the cerebellum will bring into view the floor of the fourth ventricle. In fatal concussion ecchymotic spots varying in number and extent are usually found here. Care should be taken not to confuse the prominent veins usually found on either side of the anterior part of the floor of the fourth ventricle, with ecchymoses.

Contusion of the brain is practically a minute surface laceration of the cortex. It is marked by red spots that remain after pressure on the pia and which on section prove to be a thin surface hemorrhage beneath the pia in the brain substance.

Laceration of the brain is always accompanied by hemorrhage and may be due to violence or to the effusion of blood from spontaneous rupture of a diseased vessel. In the latter case the typical location of the hemorrhage is in the lenticular nucleus, the blood having come from a rupture of one or another of the anterior perforating arteries, most commonly the lenticulo-striate. The hemorrhage and laceration may vary in extent; they may involve the inner capsule, the head of the caudate nucleus or the optic thalamus, and sometimes they extend into the ventricle; or the extension may take place in an outward direction through the outer capsule, the claustrum, and the cortex of the island of Reil. Violence, however, may cause just such a hemorrhage, although in such a case other lesions are likely to be present in addition. As a general rule, multiplicity of hemorrhages and lacerations points to violence. A spontaneous hemorrhage may occur in the usual site described above, and when the violence is due to a fall upon the back of the head following loss of consciousness multiple hemorrhages with laceration of brain tissue may occur in the brain substance and in the cortex. In laceration of the brain due to violence, the lesions are usually most marked in the cortex, on the surface, and they become less extensive in the deeper portion of the brain tissue. Such laceration may be due to a comminuted depressed fracture of the skull, the actual tearing being caused by fragments of

bone; far more commonly, however, the seat of laceration is directly opposite the point of application of violence as indicated by a lacerated scalp wound, contusion or hæmatoma of the scalp. The brain is apparently capable of enduring considerable compression without the occurrence of laceration. Where, however, the brain tissue is called upon to fill out an increased space, *i.e.*, where distention occurs, laceration results. When violence is exerted upon one point of the calvaria, the convexity of the bone is suddenly reduced, while at a point directly opposite the convexity is increased by compensation. At the point of application, therefore, the brain may be compressed without laceration, while at the opposite point the brain is distended and laceration results. With a blow or fall upon the side of the head, with a hæmatoma in the temporal or parietal region, the surface of the caudate nucleus and optic thalamus on the same side is sometimes the seat of laceration, without laceration of the temporal or parietal cortex on that side. Here, again, the cortex has been compressed and an opposite brain surface, though an internal one, has become lacerated by distention. Laceration of the cortex, although commonly occurring with fracture of the skull, either at some point in the skull cap or at its base, may also occur without fracture, the bone having been sufficiently elastic to accommodate itself, without breaking, to the sudden change in shape due to the violence. With laceration of the brain a blood clot, more or less extensive, may form between dura and pia. When the laceration does not involve the pia mater, blood may be infiltrated in the meshes of the pia arachnoid and may infiltrate the sulci beneath the pia mater.

Injuries to the Cerebral Vessels.—Isolated laceration of one or another cerebral vessel may be due to violence either with or without fracture of the skull. The vessel may or may not have previously been the seat of fatty degeneration or of aneurism. In such a case the blood is usually poured out beneath the pia mater, more commonly at the base of the brain; it may infiltrate both fissures of Sylvius, and passing beneath the velum interpositum, through the large transverse fissure, may break through the single layer of epithelium constituting the ependyma and gain access to the ventricles. An accurate examination of all the cerebral vessels is a matter of considerable importance. In the case of an aneurism, spontaneous rupture is quite possible; but when the vessels are the seat of fatty degeneration and atheroma, spontaneous rupture is infrequent, if we except the lenticulo-striate and anterior perforating branches. Atheroma will, however, account for conditions—namely, vertigo and sudden loss of consciousness—which in themselves may be responsible for the occurrence of traumatism.

Traumatic Meningitis.—Acute purulent or proliferative meningitis may occur from traumatism, and may be the immediate cause of death. Where a wound, with or without fracture of the skull, has opened the way for infection, or where fracture of the base of the skull has permitted infection through nasal, buccal, or aural orifices, the connection of a purulent meningitis with the traumatism, although indirect, is quite evident. Such a purulent meningitis may not follow the traumatism directly, as infection may take place later and is possible as long as the wound or fracture is not completely healed.

Where, however, a purulent or an acute proliferative meningitis is found without an apparent avenue of infection, but following a traumatism (as contusion of some part of the head with concussion of the brain), the connection between the meningitis and the traumatism is more difficult to establish. All other causes of meningitis would have to be excluded. In addition, the clinical history of onset of meningitis within at least a few days from reception of the traumatism, would be most important evidence. The stage of the inflammatory process as found at the autopsy is of great importance. Although it might not be possible to determine absolutely the duration of the disease, still it might be ascertained that the duration was or was not longer than a given time, namely, the date of the occurrence of the traumatism in evidence.

The important bearing of an inflammatory process, with invasion of pyogenic bacteria in some other portion of the body adjacent or remote, should not be forgotten as a possible source of infection.

The occurrence of acute exudative inflammations of serous membranes in subjects of chronic interstitial or diffuse nephritis without traumatism, would render the acceptance of these diseases as predisposing conditions of meningitis from traumatism quite plausible.

Hemorrhagic meningitis is not necessarily traumatic. It may occur as a complication of typhoid fever and other infectious diseases.

Acute pachymeningitis may be secondary to fracture of the skull, from infection, or to an infected scalp wound or erysipelas. The inflammation may affect the external layer of the dura (usually in the form of a purulent pachymeningitis) or the internal layer (in the form of a fibrinous pachymeningitis), or both layers may be inflamed.

Pachymeningitis interna hæmorrhagica may give rise to a hemorrhage with formation of clot between the dura and the pia. When one or more layers of tissue result from attacks of this form of inflammation—layers which may be stripped off from the dura—the diagnosis is readily made from a simple macroscopic examination. An excessive hemorrhage may, however, occur at an early stage when the membrane is as yet very thin, and when microscopic examination may be necessary to substantiate the diagnosis. Pachymeningitis interna hæmorrhagica must be suspected whenever a blood clot is found between the pia and the dura, especially over the convexity on one side, in the absence of laceration of the brain. Such a clot might, however, result from laceration of the veins in the pia as they pass over to the dura, to gain access to the longitudinal sinus. Pachymeningitis may at any time cause a spontaneous hemorrhage with compression of the brain and death. It is conceivable that violence, not necessarily excessive, may at any time determine such a hemorrhage; it should be remembered, however, that vertigo and loss of consciousness (common symptoms of this affection) may be responsible for the occurrence of trauma, which in its turn may determine the hemorrhage.

Meningeal Arteries.—Laceration is due to traumatism, and occurs most commonly with fracture of the skull (calvaria or base), the site of laceration corresponding to the point where the line of fracture crosses the course of the artery. Laceration may occur without fracture. The middle meningeal or one of its branches is most exposed to laceration from its course and its position in a deep groove, or even a canal, of bone. The effusion of blood occurs between dura and bone, unless the dura is completely lacerated by a comminuted depressed fracture. Compression of the brain by the resulting clot is usually sufficient, if unrelieved, to cause death. However, when the effusion of blood is not too excessive the compression may not be sufficient to cause death. A clot three inches in diameter and three-fourths of an inch in thickness compressing the right frontal lobe, and due to laceration of a branch of the anterior meningeal artery, with stellate fracture of the right orbital plate, was found in a case in which death was due to pneumothorax from perforation of a tuberculous focus. There was no history of cerebral symptoms. The organization of the peripheral part of the clot showed that it must have been present for several weeks.

As regards fracture of the skull, calvaria or base, as a cause for death, it should be remembered that the fracture in itself, except in so far as it may open the way for infection, is of minor importance. The lesions of the vessels and consequent hemorrhage, the accompanying concussion, contusion, laceration, and compression of the brain, are the important factors. The fracture is of importance, and its description should always be accurately made, as it may indicate not only the degree of violence sustained, but in addition may serve to indicate the character of the weapon employed or the manner in which the injury was sustained.

Neck.—The injuries produced by strangulation and hanging are considered under *Asphyxia.* Contusion of the larynx may cause sudden death by shock, by reflex paralysis of respiration, or by spasm of the glottis. Fractures of the laryngeal or tracheal cartilages, from the œdema of the submucous areolar tissue accompanying them, may cause occlusion of the respiratory passage and asphyxia. Laceration of the mucosa accompanying such fractures or occurring alone may be followed by cellular emphysema and by asphyxia. A case in point has been observed in which a laceration of the mucosa between the larynx and the trachea, followed by cellular emphysema of the neck, glottis, upper half of the thoracic wall, and mediastinum, although tracheotomy had been performed, caused death from asphyxia. The laceration in this case was produced by sudden over-extension of the neck, in a fall upon the chin.

Incised wounds of the neck, as in cases of suicide, may cause death from hemorrhage; more commonly, however, the larger vessels are not cut, but the incision passes between the hyoid bone and the larynx, through the larynx or trachea, into the respiratory passage. Death in such cases may be due to a complicating broncho-pneumonia from aspiration of the discharges from the wound.

Direct contusion of the posterior part of the neck may be accompanied by contusion of the medulla and spinal cord without fracture of the cervical vertebræ.

Fracture and dislocation of the cervical vertebræ are more often due to a fall or blow upon the vertex of the cranium than to direct violence upon the neck.

A wound of the jugular veins immediately above the thorax may be followed by entrance of air into the right heart and pulmonary circulation, causing sudden death.

Thorax.—Simple fracture of the ribs is not usually in itself a cause of death. If, however, an intercostal artery has been lacerated, or the lung or the heart punctured, death may follow hemorrhage or pneumothorax.

Compound fracture may be followed by cellular emphysema, and, if perforation of the pleural sac has occurred, by pneumothorax.

Contusion and laceration of the lung may accompany fractured ribs, or there may be few or no signs of violence in the thoracic wall. This is particularly apt to be the case in children. These lesions may produce ecchymoses, parenchymatous hemorrhages, interstitial emphysema, or pneumothorax.

Pneumothorax may result from the perforation of a tuberculous focus into the pleural sac.

Wounds of the lung may cause death by hemorrhage, pneumothorax, cellular emphysema, or by complicating pneumonia.

Pneumonia may be secondary to cerebral injuries, and to other injuries besides those of the respiratory tract mentioned. Infection of wounds may explain a secondary pneumonia in some cases; in others a condition of passive hyperæmia, followed by "hypostatic" pneumonia, may be due to the confinement and enfeebled condition following such injuries, or to the advanced age of the individual.

Rupture of the heart may be spontaneous and due to fatty degeneration or necrosis of a portion of its wall from occlusion of the afferent branch of the coronary artery. Such rupture usually occurs in the anterior wall of the left ventricle. Contusion and laceration of the heart may occur from direct contusion, or from compression of the thorax. In the latter case, laceration is far more likely to occur in the wall of the right auricle. Laceration of the posterior wall of the left ventricle, where it comes in relation with the tendon of the diaphragm, was found in case of fall from a height; the accompanying lesions, in this case, being contusions, fractured ribs, and lacerations of both lungs.

Stab and bullet wounds of the heart cause death through the compression exerted upon the heart by the effused blood in the pericardial sac. This serves to explain the fact that death in such cases is not necessarily instantaneous. A few cases of recovery from such wounds are on record. Depending upon the character of the wound and the rapidity or slowness of the resulting hemorrhage, a shorter or longer period may intervene between reception of the injury and death. Voluntary action may occur after a wound of the heart has been received. Thus the wounded person may run a short distance, or may close the clasp knife with which the wound had been inflicted. Multiple bullet wounds of the heart have been self-inflicted, usually with weapons of small calibre. Multiple self-inflicted stab wounds of the heart and other organs are on record.

Fatty embolism of the pulmonary artery may follow fractures of cancellous bone, especially if considerable comminution occurs. Embolism of the pulmonary arteries may also occur as a result of a primary peripheral thrombo-phlebitis due to injury.

Aneurisms in this region may rupture spontaneously, or rupture may follow an injury of comparatively minor violence.

Abdomen.—Shock with comparatively slight evidences of injury due to contusion of the abdomen or of the solar plexus, may occur. Contusion, compression, and laceration of organs without apparent injury of the abdominal wall, are not infrequent. Laceration of an artery may occur alone from traumatism, and without previous disease. In other cases the artery may be the seat of some disease like aneurism or tuberculosis, and a spontaneous hæmatoma or hemorrhage may occur, or such hemorrhage may be the result of an injury otherwise of insufficient violence to cause rupture. Septic peritonitis may follow perforation of a hollow viscus due to disease, or perforation may have been immediately brought about by injury. Hemorrhagic peritonitis, hemorrhagic pancreatitis, with or without fat necrosis, may be mistaken for the results of injury. Hæmatoma of the suprarenal capsule due to excessive passive hyperæmia, with or without rupture into the peritoneal cavity, is another condition that may be mistaken for the result of violence.

Pelvis.—Spontaneous rupture of the bladder without disease may occur in subjects of hysteria. A case with fatal hemorrhage, in which traumatism was absolutely excluded, has come to notice. Septicæmia may follow infiltration of urine due to careless catheterization. Injury to the female genitalia, not only in cases of criminal abortion but also in non-pregnant cases, may be produced by direct violence, or during coitus. Such injuries are commonly lacerations of various extent, either simply involving the hymen or ostium vaginæ, or extending upward into the vagina, or involving the fornix and perforating into the peritoneal cavity. In such cases death may be due to hemorrhage, or to septicæmia, or to septic peritonitis. Rupture of the pregnant uterus may be the result of a fall or blow; on the other hand it may occur spontaneously. In the latter case, however, rupture occurs after labor pains—that is, contractions of the uterus—have set in, and usually after a more or less prolonged duration of labor due to obstruction to delivery.

ABORTION.—The questions for investigation are: Has abortion occurred? If so, has it been induced? Is it responsible for the death of the individual?

Abortion may be defined as the termination of gestation before the viability of the fœtus, this term being accepted as about thirty weeks or seven calendar months. The conditions post mortem upon which the diagnosis of gestation that has been terminated may be based, may readily be remembered by recapitulating the changes produced in the uterus and ovary by gestation. If in addition some portion of the products of conception is still retained in utero, its demonstration affords positive proof. Nevertheless, if no such portion be found, the changes produced in the uterus and ovary are sufficiently characteristic, provided too long a time has not elapsed, to warrant a positive diagnosis.

If a portion of the fœtus, or its membranes, more especially chorionic or placental villi, be demonstrated, this alone is proof of gestation, but is not in itself proof of criminal abortion. The signs, so far as the uterus and ovary are concerned, may individually, at least in part, be

produced by other conditions. These signs are, in the first place, enlargement of the uterus, especially its body, and enlargement of its cavity; second, hypertrophy of the uterine wall, a softer consistency, and enlargement of its veins with formation of sinuses, especially at the placental site; third, thickening of the endometrium with the characteristic change in its morphology—namely, the production of the true decidua of pregnancy, and over the anterior or posterior wall at the fundus, where the chorionic villi become attached to the decidua serotina, the formation of the placenta. Even though all the chorionic portion of the placenta has been separated, a raw surface is left, differing from the otherwise smooth lining, which can readily be recognized, even from the gross appearances, as the placental site.

The size of the uterus will vary, in the first place, according to the period of gestation that has been reached, and, in the second place, according to the time elapsed between the cessation of gestation or abortion and death. The consistency of the uterus will vary according to the period of gestation, the presence or absence of metritis, and the advancement of post-mortem changes. The decidua will vary according to the time at which gestation was interfered with, according to the time which has elapsed between then and death, and also according to the degree of inflammatory reaction that may have taken place.

The ovary that has supplied the ovule which has been fructified presents a change in its Graafian follicle that is quite characteristic, especially in the earlier periods of gestation, namely, the true corpus luteum. At the end of the third week, this presents a cyst of 2 cm. in diameter, with a wall 3 mm. in thickness and of a characteristic yellow color, usually distended at this period. Shortly thereafter this wall shows a slight convolution, while the cavity is often filled with a clear, slightly viscid fluid, sometimes blood-tinged, or entirely bloody. From this period onward the change consists in a gradual shrinkage of the entire cyst with more marked convolution of its yellow wall, and with absorption of its fluid contents, coincident with a growth of connective tissue which occupies the place of the fluid. The corpus luteum persists throughout the entire period of gestation, and does not diminish markedly in size until the end of four or five months. Although in structure the corpus luteum of pregnancy does not differ from the normal corpus luteum of menstruation, yet from its larger size, and its persistence in size up to the fourth or fifth month, together with the thickness of its yellow border, it forms a valuable additional sign of gestation, especially during the period when criminal abortion is more commonly committed. The corpus luteum of menstruation under certain diseased conditions—as, for instance, when there are fibroid tumors of the uterus, or cystic oöphoritis—may reach 1 cm. or even more in diameter. It is then filled with clotted blood, has a yellow margin, is sometimes convoluted, and measures 1 or 2 mm. in thickness; yet its appearance, when one has become familiar with the true corpus luteum of pregnancy, is quite different. Moreover, a number of such corpora lutea are usually found. The absence of diseased conditions in which they occur would be additional evidence in doubtful cases.

To recapitulate, the only positive evidences that a fœtus in utero has existed are these: The presence of chorionic villi, which from their adhesion to the placental site may be readily enough found, and the demonstration of a true decidua of pregnancy, both of which structures must have their true character verified by microscopical examination. To these two, perhaps, should be added a third, viz., the demonstration of a true corpus luteum in one or the other ovary. All the other signs are not in themselves positive, but taken together they may form sufficient evidence of recent gestation.

Signs of Abortion having been Induced.—Induction of abortion may under certain circumstances and after consultation be perfectly justifiable. When there is no lawful reason for the termination of gestation, induction of abortion is criminal. What signs may we rely upon, in the post-mortem examination, to conclude that abortion has been criminally induced? In the first place, the examination of the fornix of the vagina and cervical canal, especially at and just below the internal os, for punctures and lacerations, may furnish strong evidence of such interference. A large number of cases of criminal abortion are produced by mechanical means, employed by persons lacking anatomical knowledge and surgical skill. A stylet, sound, catheter, or syringe is introduced, or the cervix is clumsily dilated with some instrument, all these procedures leaving a mark by reason of their unskilful employment. Examination of the fundus, the anterior wall or the posterior wall of the uterus may show a partial or complete puncture or laceration. The effect of certain corrosive fluids may be quite noticeable upon the endometrium, for these fluids—such as carbolic acid or bichloride of mercury solutions—are sometimes used as intra-uterine injections for the production of abortion.

The effects of the mechanical means mentioned above are, to cause the uterus completely to empty itself; and, provided the woman escape infection or withstand it, death may not result. In many cases, however, the abortion remains incomplete and hemorrhage from the partially separated placenta, or from the actual lesions, lacerations, or perforations produced, may prove fatal. Or infection may take place, and death may result from a septic endometritis, metritis, parametritis, and peritonitis.

Besides mechanical means for the induction of abortion, there are numerous drugs and nostrums which are taken internally for this purpose. The danger in their use is twofold: in the first place they may cause direct poisoning, since many of them in increased doses are intense gastro-intestinal irritants; in the second place, the effect is usually partial, the fœtus being killed but not expelled, or its membranes and the placenta are either incompletely expelled, or they remain in the uterus and subsequently lead to death from hemorrhage or from septic infection.

Asphyxia.—Asphyia may be due to mechanical causes preventing the entrance of oxygen into the lungs, or interfering with the movements of respiration; or it may be due to the presence of irrespirable gases or to causes acting upon the respiratory centre in the medulla. The following list includes many of the different ways in which asphyxia may be produced in a mechanical manner: Occlusion of the mouth and nose, larynx, trachea, and bronchi, either by foreign bodies or by intrinsic tumors; occlusion of these same channels by pressure exerted from the outside—as by an aneurism, a new growth, or an enlarged thyroid gland, or by an accumulation of fluid or air in the pleural sac; compression of the chest wall, direct compression of the trachea, or more commonly the compression of the hyoid bone, base of the tongue, and epiglottis, over the aditus laryngis, as in strangulation; aspiration of stomach contents in vomiting; entrance of pus from a tuberculous lymph node which in breaking down has perforated the trachea or bronchus; submersion as in drowning, or conditions in which the mouth and nose alone become submerged below the level of the fluid, as in some cases of death of the new-born, or of intoxicated or unconscious persons.

For information in regard to the various forms of poisoning by carbonic acid gas, see the article entitled *Carbon, Hydrides and Oxides of.*

Asphyxia may be caused by inhalation of irrespirable gases such as chlorine, bromine, iodine, nitrous acid, sulphurous acid, and sulphureted hydrogen. In these cases death is usually caused immediately by the shutting off of oxygen. There have been cases in which death has occurred, some time after such exposure, from bronchopneumonia. In regard to sulphureted hydrogen, it has been thought that it forms a compound with hæmoglobin. If the gas is passed through blood the latter becomes dirty greenish in color and shows a spectrum somewhat like that of oxyhæmoglobin, but with an absorption band in the red. The blood, in cases of death by asphyxia from sulphureted hydrogen, does not show this spectrum. In animals killed by exposure to sulphureted hydrogen much less gas is required (one-tenth to one-half per cent.)

than is needed to cause the appearance of the sulphuretted hydrogen spectrum in their blood.

The respiratory centre in the medulla may be the seat of various pathological alterations: there may be some gross injury, or a hemorrhage may have taken place, either of traumatic origin or the result of disease; or the medulla may be compressed by a new growth, or it may be directly affected by the action of drugs capable of causing a paralysis of respiration.

When respiration has been suddenly interfered with by any of the foregoing causes, ecchymotic spots, varying in size from 1 mm. to 1 cm. in diameter, are usually found in the visceral and parietal pleura, the mediastinal pleura, the visceral pericardium, sometimes the parietal pericardium, the endocardium, the meninges, and more rarely the peritoneum. This sign is a valuable one, although not in itself absolutely diagnostic of asphyxia. In cases of slow asphyxiation no ecchymoses may be found.

Again, ecchymoses may be found in these sites in conditions other than asphyxia, namely, in septicæmia, purpura hæmorrhagica, nephritis, hemorrhagic pleuritis, pericarditis and peritonitis, in many infectious diseases, and in poisoning by phosphorus, arsenic, and other poisons. When, however, these conditions can be excluded the presence of ecchymoses indicates asphyxia: their absence does not exclude asphyxia, if other conditions are present upon which the diagnosis can be based. In some cases of sudden occlusion of the larynx by a foreign body, as a piece of meat, or by a laryngeal tumor, death occurs very suddenly, apparently by reflex paralysis of respiration. The same condition is sometimes met with in infants with very large thymus glands, yet in these cases, in spite of the sudden cessation of respiration, ecchymoses may be entirely absent.

When death is due to occlusion by a foreign body, by aspiration of vomit, or by the other conditions described above, these will be apparent at the autopsy and in most cases the ecchymotic spots will be present also. The blood is usually fluid, very dark, from reduced hæmoglobin, and distends the right auricle and ventricle, pulmonary artery and vena cava. The lips and the skin of the face and neck may be cyanotic.

In deaths from smothering or overlying, the ecchymoses are almost invariably found. The lungs and the bronchial mucosa are usually intensely congested; there may be vesicular emphysema, more especially of the anterior edges and external margins at the base of the lung; in some places an actual rupture of vesicles takes place, with suffusion of air beneath the pleura, probably from spasmodic expiratory efforts. The brain is intensely congested, the face is usually markedly cyanotic, the lips almost black. The internal organs are engorged with dark fluid blood; the pulmonary artery, right auricle and ventricle are distended with dark blood, mostly fluid, rarely and then poorly clotted.

When death is due to strangulation by garroting or to compression by the hands, scratch marks are usually found over the neck and sometimes upon the chin and cheeks. The hyoid bone and base of the tongue with the epiglottis may be found pressed over and occluding the aditus laryngis. There is usually contusion of muscles and fascia and effusion of blood into the loose areolar tissue. There may be fracture of the hyoid bone, of the thyroid cartilage, or of tracheal rings.

In asphyxia due to strangulation by hanging, the mark of the cord or band is usually found about the neck forming a single or double furrow whose depth is pale, and whose margins are deeply congested, and under which in the connective tissue and muscle the effects of contusion, laceration, and hemorrhage are found. Laceration of the intima of the arteries at the site of compression may occur. The course of this furrow may vary, and according to the position of the knot or loop of the noose a convergence behind one or the other ear, under the angle of the jaw on either side, under the chin, or under the occiput may be apparent. The trachea may be compressed and some of its rings broken, the thyroid cartilage or the hyoid bone may be fractured, or most commonly the hyoid bone with the base of the tongue and the epiglottis is pressed backward, occluding the opening of the larynx.

The tongue may be pressed forward and clenched between the teeth. Cyanosis of the head and neck above the furrow may be present. Fluidity and dark color of the blood, ecchymoses, and general passive hyperæmia, especially of the lungs and brain, may all be present.

It is possible that death may be caused by compression of the vagi, with sudden paralysis of respiration and heart action, in which case cyanosis, excessive hyperæmia, and ecchymoses may be absent or poorly marked.

In some cases of hanging, with the loop or knot placed behind the ear, and with sudden tension of the body weight upon the noose, fracture or dislocation of the atlas upon the axis, with crushing of the medulla by the odontoid process, occurs, and death is instantaneous. The signs mentioned above might then be absent.

In asphyxia by submersion, as in drowning, or where mouth and nose are alone submerged, the lungs are increased in size and weight, and congested, the bronchi are filled with a frothy fluid, and on section a considerable amount of fluid escapes. The condition is quite different from an ordinary œdema, even though very excessive. It is not possible to diagnose submersion with certainty, from chemical examination of the fluid in the lung, as one might at first think. If specific substances are contained in the fluid, for instance such as portions of vegetable matter, liquor amnii and its contents, such a diagnosis might be positively made by microscopical examination. In addition to the water in the lungs, which is very probably aspirated in the last moments of life, there is usually in the stomach a considerable amount of fluid that has been swallowed. The question may arise as to whether or not in a given case in which a body has been removed from the water, death was due to drowning. If the above signs are present the cause of death would be asphyxia by submersion, since if life is extinct water cannot gain access to the lungs or stomach. On the other hand, if these signs are absent it might not be safe to reason that life was extinct before the body entered the water, since it is conceivable that in an unconscious condition there might be no struggle, no dyspnœa, and consequently no swallowing or aspiration of water.

Infanticide.—The following points should be determined:

1. The viability of the fœtus; that is, whether it can be assumed that the fœtus was capable of sustaining life.
2. Was the child born alive, or in a state of suspended animation?
3. The immediate cause of death.

The accepted period of utero-gestation, upon the termination of which the fœtus is viable and capable of sustaining life under favorable conditions, is reckoned as thirty weeks. Some cases have been reported in which the infant was born alive at twenty weeks, and some even at twenty-five weeks have been capable of sustaining life for a longer or shorter time. At thirty weeks the fœtus is 40 cm. in length. Its weight varies from 1,500 to 2,000 gm. The skin is covered with fine hair, the finger nails reach the tips of the fingers, the pupillary membrane is either absent or only a vestige remains, the testicles have descended or at least are in the canal, the centre of ossification in the os calcis is 5 mm. in diameter, that in the astragalus half that size. There are no centres of ossification in the epiphyses at the knee.

The presence of air in pulmonary vesicles, provided decomposition or direct mechanical inflation can be excluded, is plain evidence that the child has breathed, although it is not necessarily evidence that complete birth alive has occurred. Inspiratory movements and aspiration of air may even occur in utero during obstetrical manipulations or operations, and it is conceivable that after birth of the head inspiration may occur and through delay asphyxia may take place. Again, it is well known that a child may be born in a condition of apnœa, and even after it has remained for hours in a condition almost resembling death, with an occasional heart beat, it may finally

be resuscitated by artificial respiration. In such cases, although the child is born alive, it may never have breathed, and consequently the lungs will be found in a condition of fetal atelectasis. In some of these cases the presence of air in the stomach or intestine, provided decomposition can be excluded, may be the only sign of this condition. In other cases aëration of the lungs of the fœtus may be interfered with by the presence of some pathological condition of the lungs, namely hepatization, due to desquamation and fatty degeneration of respiratory epithelium (forming whitish areas), by the presence of an interstitial pneumonia, or by compression of the lungs by the abdominal organs (either from partial absence of the diaphragm or from a large cystic kidney). Again, by the aspiration of liquor amnii or blood, or by the membranes being unruptured, or, though ruptured, by a portion thereof occluding mouth and nose, the lungs may fail to become aërated although the child was born alive.

The differential diagnosis between atelectasis and aëration of the lung from inspiration is practically and readily made even from a gross examination, provided decomposition is not excessive; in fact, it can be made even though decomposition be considerably advanced. The atelectatic lung is smaller, and therefore the vault of the diaphragm is higher (at the third rib or intercostal space). When inspiration has occurred the lung is increased in volume, and the vault of the diaphragm is found at the level of the sixth rib. Atelectatic lung is denser and darker in color, its edges are sharper, it does not crepitate, and it cuts like liver, differing from hepatization due to inflammation in the absence of a granular surface on section, and in the absence of pleuritis. The consistence of aërated lung is softer, it crepitates on pressure, is light red in color, and presents on the surface and on section a characteristic mottled appearance due to the occurrence of aërated vesicles between areas of blood-vessels. Magnified by an ordinary hand lens the aëration is seen to be distributed throughout all the vesicles in the area. In this it differs from the appearance presented by vesicles which are filled with gas due to decomposition, for this gas is never distributed in such a regular manner. Aërated lung may become dark from congestion, and often enough post mortem the posterior portions are found congested and dark, while the anterior or upper portions are quite light. Such hypostatic congestion is not at all a marked feature in atelectatic lungs when respiration has not taken place. Moreover, in the aërated lung, on scraping the section frothy blood is found; while in the atelectatic lung, from which air is absent, blood if present in any amount is fluid.

The specific gravity of the lung tissue itself being rather low, when any air is present in its meshes it readily floats. This is called the hydrostatic test, and is quite reliable under certain limitations. It must be remembered that if a lung or portion of a lung floats, it simply means that it contains air or gas, which may be the air of inspiration or the gas of decomposition. Therefore, if decomposition can be excluded and the lung floats, it is a positive evidence of aëration. Even though decomposition be present, it may still be possible to determine the fact that the lung is aërated; for the gas is never as finely distributed throughout the air vesicles as is the air in an aërated lung, but occurs in larger bubbles throughout the tissue. If after these are pricked and the piece of lung is squeezed, it still floats, it is highly probable that the lung is aërated, since it is difficult entirely to squeeze out all the air from aërated lung tissue. Another point in regard to decomposition depends upon the fact that this process develops earlier in the liver and spleen than in the lung. If portions of spleen or liver float, and the lung does not, it is positive evidence of atelectasis.

All the other tests are not as reliable as the examination of the lung and the demonstration, under the restrictions given above, that air is or is not present in the stomach and intestines. In uncommon cases a child may breathe for a number of hours, or even days, and then die with atelectasis, usually partial and only rarely complete.

It may be necessary to determine, if possible, the length of time that the child lived. The appearance of the umbilical cord with attached placenta, or of only a portion of the cord, in a moist and white condition, is a very reliable sign of a recently born infant. The same may be said of the presence, in abundance, of the vernix caseosa. If, however, the umbilical cord is dry and mummified, this does not necessarily mean that the child has lived a number of days, since the same drying may occur post mortem. A better criterion is found in the retrogressive changes of atrophy in the umbilical arteries, and later in the umbilical vein. The appearance of the umbilicus, if the cord has come away, may not be a reliable criterion, inasmuch as it may have been torn out in the fresh state, or may have dried off, or have been torn off post mortem. If, however, some granulation tissue is present, this might be of help in approximately determining the age—for the cord usually separates after the lapse of from four to seven days. The so-called fetal vessels, besides the umbilical arteries,—namely, the umbilical vein, the ductus arterio-venosus, and the foramen ovale—may remain patent for a week or two, so that this does not help us in absolutely determining the age within the first week. The presence of food in the stomach is of course a valuable sign that the child has lived. The caput succedaneum is a reliable sign of a recently born child, and should not be mistaken for an ordinary hæmatoma.

In determining the immediate cause of death special care is necessary to avoid mistaking normal fissures and divisions of the cranial bones for fractures, and also not to misinterpret the peculiar rachitic growth of bone both in the skull and in the long bones for fractures. In cases of passive hyperæmia with patent ductus arterio-venosus, a hæmatoma may form in the medulla of the suprarenal gland and may even rupture into the peritoneal cavity, thus simulating a traumatism. In cases of melæna neonatorum an effusion of blood may occur in the stomach or in the intestine, or in the loose areolar tissue about the kidney and behind the peritoneum.

Special care should be used to avoid the production of artifacts in the removal of the tongue, fauces, soft palate, pharynx, larynx, etc., together, as already described, and a careful search should be made for evidences of injury or lodgment of foreign particles, or lacerations which may have been produced by the finger having been passed into the pharynx to cut off respiration. What has been said about other causes of death, both traumatism and poisons, applies of course to infants as well.

Death from Electric Shock.—The medico-legal importance of death from lightning stroke is slight. Postmortem appearances may be negative or the cadaver may present peculiar arborescent markings of the skin, probably due to vaso-motor paralysis and subsequent decomposition. Internally, lacerations of various organs have been described and even fractures, but the conditions are not constant.

Death from currents of high electro-motive force (fifteen hundred to two thousand volts).—The skin and subcutaneous tissues may be burned even down to the bone, in parts that have come in contact with the wire or other charged object, or, as has sometimes been observed, the cadaver may show no external signs whatever. The post-mortem conditions are not sufficiently characteristic, unless such burns are present, to base a diagnosis of death from electric current upon them. They are practically the signs that are seen in other conditions producing asphyxia. The blood is fluid, the right side of the heart being filled and dilated. The left ventricle may be contracted. There may be ecchymoses in the endocardium, in the pericardium, in the pleura, and rarely in the peritoneum. There may be minute hemorrhages in the floor of the fourth ventricle. The blood is dark in color.

Death from Burns and Scalds.—Deaths in conflagrations are, more commonly than is generally believed,

due to asphyxia from inhalation of smoke, or to actual burns of the respiratory passages and acute œdema of the glottis from the inhalation of hot air or flame. Post-mortem appearances in such conditions are discussed under *Asphyxia*. When death occurs from actual burns,—as may happen, for example, as a result of a conflagration,—it will be found that the extent of cutaneous surface burned is a more serious factor than the mere depth of the burn. Although cases have recovered in which a greater area has been involved, if one-third of the surface of the cutis is burned the individual usually dies. The cause of death in these cases may be shock, or it may be due, judging from post-mortem appearances, to the action of some poisonous substance either absorbed from the wound surface (namely, some ptomaïne-like product), or from the invasion of bacteria, or from an auto-intoxication due to suspension of function of the skin involved. The heart muscle and the epithelial cells of the liver and kidney present the appearances of parenchymatous degeneration, or, if death occurs somewhat later, of fatty degeneration. It has been reported that round ulcer of the duodenum is a frequent accompaniment of extensive burns. It is supposed to be due to ecchymosis of the mucous membrane and subsequent erosion. In many cases of fatal burns, however, such ulcers are not found.

The external appearances of the burns vary with the degree. A burn that during life has merely produced erythema may, by reason of the post-mortem distribution of the blood, escape attention after death. If the burn is intense the spot may remain, and forms good evidence of the burn having been produced during life. Even though redness may have vanished, the epidermis may show some change. In burns of the second degree vesicles are produced, serum exuding in the lower layers of the epidermis, and lifting up the horny layer. These vesicles may be small or large, and after death they may remain unbroken, and may be surrounded by an area of hyperæmia, or the latter appearance may be absent. If the vesicle has been broken, and if this has recently occurred, the denuded corium underneath is moist and light in color, and the shrivelled epidermis may still be partly attached. If, however, the part has been exposed to air for a longer time the denuded corium becomes dry, hard, yellowish or yellowish brown, or dark brown in color, and like leather or parchment in consistence. In burns of the third degree involving the corium down to the subcutaneous tissue, if recently produced by scalding, the tissue may be white or grayish white, as if cooked, from coagulation necrosis, or, if produced by a burn, may present the appearance of having been roasted. The vesicle filled with serum is a fairly good indication of a burn having occurred during life. Although some have claimed to have been able to produce such vesicles post mortem, in most of the experiments performed on the cadaver such vesicles contain gas but not serum. When burns of the third degree have occurred during life, the blood in the vessels is immediately coagulated. If a burn is produced post mortem, unless possibly in a dependent portion of the cadaver, the coagulated blood will be found only in the veins and capillaries, and not in the arteries as well. Histological examination of such tissue may, under these circumstances, prove of value. It is said that the network presented post mortem by leathery, dried-out burns, is due to the coagulation of blood in the vessels, and if the burn has been produced during life such a network is very much finer than if the burn is produced after death.

Where complete charring of the skin has been produced in conflagrations spontaneous rupture may occur, its usual site being the flexor aspects of joints and the perineum. Such spontaneous lacerations have been mistaken for wounds. They present, however, no reaction, no hemorrhage, and through the adipose tissue from one surface of the laceration to the other, vessels and nerves may pass. With the charring of the skin, rupture not having as yet occurred, a contracture and shrivelling of the tissue beneath may take place. The charred skin protects the underlying parts from further charring. On this account complete incineration at conflagrations does not usually occur. Besides a bursting of the scalp, fracture of the bone or the formation of holes in the bone with exfoliation of burned bone after charring, or in addition a diastasis of the sutures or an actual fracture of the skull, produced by the vapor from the tissues within the cranium being subjected to a high degree of heat, may occur. Such conditions may be mistaken for the results of inflicted violence. If injury has been sustained during life hemorrhage occurs, or the tissues may become infiltrated with blood as already discussed. If evidence of such reaction is found the injury must have occurred during life. Another valuable criterion is the examination for carbon monoxide hæmoglobin in the blood that has not been exposed externally. The demonstration of carbon monoxide in the blood in internal parts that could not have come in contact with carbon monoxide after death clearly proves that carbon monoxide was inhaled. This test may be of value in determining whether life was extinct or not when the individual was exposed to the smoke.

The question may arise as to the time which must have elapsed before the effects found in charring of the body could have been produced. It has been found that an hour's exposure to flame will cause a complete charring of the soft tissues, and a further hour's exposure to the heat of glowing embers will cause calcining of the bones of a newly born child. At conflagrations the result is probably produced after a much longer exposure. The exact time might be very difficult to determine.

The identification of charred bodies or portions thereof may present great difficulties. The marked shrinkage of the tissues (with the exception of bone), due to prolonged exposure to heat, should be remembered. A case is reported in which a part found consisted of a pelvis, clearly that of a male adult, which was embedded in a mass about the size of a man's head. In it were also found the heart, liver, coils of intestine, and the external genitalia which were very small. The organs presented an appearance that would have led one to estimate the age of the subject as between four and six years. The bones, although completely charred, may still sufficiently sustain their form to be a valuable guide in determining probable age, or, at least, height of the subject, and the pelvis may aid in determining the sex after puberty.

DEATH FROM EXPOSURE TO COLD.—Appearances due to frost bite may or may not be present. Light red spots of post-mortem decomposition are supposed to be characteristic by some and are denied by others. The heart and central veins have been described as abnormally filled with blood, this being supposed to be due to contracture of the peripheral part of the vascular system. The diagnosis must be made by exclusion, and from the circumstances of the case.

DEATH FROM STARVATION.—The proof of this may be of medico-legal importance, more especially in cases of children who have been subjected to cruel and inhuman treatment. The blood is markedly anæmic and clotted, and may be quite thick in cases in which the subject has in addition been deprived of water. The heart may be small, soft, and flabby. The liver, spleen, and kidneys may be smaller than is natural, from atrophy. Stomach and small intestine may be empty, and there is a marked diminution of subcutaneous fat and also of internal fat, namely, in the omentum, mesentery, perinephritic tissue, and subpericardial tissue. Fat, however, is never entirely absent. The external appearance of the cadaver presents the characteristic appearance of marked emaciation.

Otto H. Schultze.

AVA. See *Kava*.

AVENS.—Under this name are known various species of the genus *Geum* L. (Fam. *Rosaceæ*), of which there are some thirty or forty, distributed through both temperate zones, especially the northern. By Avens is generally understood the rhizome and root of *G. urbanum* L., while that of *G. rivale* L. is known as Purple Avens, in al-

lusion to the purple flowers of the plant. *G. Virginianum* L. and some others are known as White Avens. None of them is much used at present, but they were formerly largely employed, both in domestic and in professional practice, as astringents and tonics. They contain volatile oils, amaroids, and much tannin. The oil quickly disappears from them in and after drying. The combination of tannin and volatile oil (when fresh or recently dried) gives them a much better control of summer diarrhœas than do drugs which are astringent merely, and this is their proper field of usefulness. They are given in doses of 1 to 4 gm. (ʒ ¼ to 1). *H. H. Rusby.*

AVON SULPHUR SPRINGS.—Livingston County, New York.

POST-OFFICE.—Avon. Hotel.

ACCESS.—Branches of the Erie system extend in four directions from Avon, forming direct communication with New York, 367 miles distant, Rochester 18 miles, and Buffalo, 66 miles. The village has a surpassingly beautiful location, nestled as it is in the charming and picturesque valley of the Genesee. The springs are on a somewhat lower level, about three-quarters of a mile from the village. The surrounding country is delightfully interspersed with fine drives, charming lakes, streams, etc. The use of the Avon Springs for medicinal purposes dates from 1792. Those found to possess the greatest efficacy are known as the "Upper" and the "Lower" spring. The "Congress" and the "Magnesia" springs are also used to some extent, the latter being the favorite for drinking. The following analyses show the chemical ingredients in one United States gallon of three of the springs:

Solids.	Upper Spring, J. Hadley, analyst. Grains.	Lower Spring, J. R. Chilton, analyst. Grains.	Congress Hall Spring, H. M. Baker, analyst. Grains.
Calcium carbonate	8.00	29.33	9.25
Sodium sulphate	16.00	13.73	21.02
Calcium sulphate	84.00	57.44	27.61
Magnesium sulphate	10.00	49.61	19.07
Sodium chloride	18.40	....	29.11
Calcium chloride	....	8.41	
Sodium iodide	....	Trace.	
Sodium sulphide } Calcium sulphide }	....	....	99.55
Total	136.40	158.52	205.61
Gases.	**Cubic inches.**	**Cubic inches.**	**Cubic inches.**
Sulphureted hydrogen	12.00	10.02	27.63
Carbonic acid	5.60	3.92	22.04
Oxygen	....	0.56	0.97
Nitrogen	....	5.42	3.88
Total	17.60	19.92	54.52

These waters are of the saline-calcic, sulpho-carbonated variety. The chemical constituents of the magnesia spring are believed to be quite similar to those of the lower spring, with, however, a greater proportion of sulphate of magnesia. In consequence of the considerable proportion of this ingredient the two latter springs have valuable laxative and purgative properties. They thus become useful in disorders of the gastro-intestinal tract accompanied by torpor of the liver and constipation. The water also produces an increased activity of the functions of the skin, and free diaphoresis often ensues. The water also possesses antacid properties and has been found of special benefit in cases of dyspepsia attended by flatulence, heart-burn, and gastric catarrh. Both internally and in the form of baths, these waters have been found beneficial in cases of obstinate rheumatism, diseases of the urinary tract, and in various skin disorders. Facilities for all kinds of hot, cold and electric baths are supplied. *James K. Crook.*

AXILLA. See *Shoulder*.

AXOCOPAN.—Municipality of Axocopan, State of Puebla, Mexico.

These springs are located in a romantic region surrounded by beautiful and picturesque scenery, about 5 km. east of the city of Atlexco. To the east of the location of the springs is the famous hill of San Miguel, noted for its religious associations. The view to the west is cut off by a succession of hills of volcanic origin, while on the north loom up the magnificent volcanoes of Popocatapetl and Ixtaccihuatl. To the northeast is the volcano of Malintzin, while the blue dome of the tropical sky surmounts the whole. Luxuriant vegetation embracing many varieties of trees and flowers surrounds the location of the springs. The waters of these springs resemble those of Vichy in France. They are naturally cold, perfectly transparent, and have a snappy and piquant sparkle from the presence of carbonic acid gas in great abundance. According to an analysis by Carrasco, the waters contain the bicarbonates of sodium, calcium, magnesium, potassium, and iron, sulphate of sodium, chloride of sodium, silicate of alumina, silicic acid, and a small percentage of organic matter. These waters are said to be exceedingly agreeable to the palate. They stand transportation well and will no doubt eventually find their way into the markets. The location of the springs offers an unusual combination of attractions for the establishment of a popular health resort. Bathing in the open air may here be indulged in throughout the year. The waters are said to be useful in diabetes, lithiasis, gastric disorders, and especially in diseases of the skin. *N. J. Ponce de Léon.*

AYAPANA. See *Thoroughwort*.

AYER'S AMHERST MINERAL SPRINGS.—Erie County, New York.

POST-OFFICE.—Williamsville. Hotel.

ACCESS.—The Buffalo and Williamsville trolley line is a mile and a half distant. The springs are four miles, two miles, and four miles respectively from the following railroad stations: the West Shore, the Lehigh Valley, and the New York Central (branch). The springs (two in number) are owned by Mr. A. D. Ayer, and are located in the town of Amherst, two miles northeast of Williamsville and six miles from Buffalo. The principal spring (artesian) was bored about ten years ago. According to a partial qualitative analysis by Herbert M. Hill, Ph.D., Professor of Chemistry and Toxicology at the University of Buffalo, it contains the following ingredients: Calcium sulphate, iron bicarbonate, calcium bicarbonate, magnesium sulphate, sodium chloride.

It is not possible to classify the water from this analysis, but it would appear to be a calcic chalybeate, with sufficient Epsom salts to give it laxative properties. A complete quantitative analysis is desirable.

The water is highly recommended for chronic constipation, sick headache, dyspepsia and gastric catarrh, hemorrhoids, and other conditions due to a disordered state of the gastro-intestinal tract. The building of a sanitarium at the springs is under contemplation.

J. K. Crook.

AZEDARACH.—*Pride of China (or of India). Chinaberry Tree.* The bark of the root of *Melia Azedarach* L. (fam. *Meliaceæ*). This is a fine, medium-sized, ornamental tree from India, but long cultivated in all the warmer parts of the world. It has delicate, twice pinnated leaves, fragrant clusters of lilac-colored flowers, and yellow globose fruits of the size of small grapes. Azedarach has been occasionally used for one or another purpose in various countries where it grows, and, in deference to a slight reputation in the Southern States was some time ago admitted to the Pharmacopœia. It is now, however, excepting as an extemporary country medicine, nearly obsolete. The bark of the root is thus described: "In curved pieces or quills, varying in size and thickness; outer surface red brown, with irregular, blackish, longitudinal ridges; inner surface whitish or

brownish; longitudinally striate; fracture more or less fibrous; upon transverse section tangentially striate, with yellowish bast fibres; almost inodorous, sweetish, afterward bitter and nauseous."

It contains a whitish-yellow resin, which is claimed to be the active principle.

Azedarach disturbs the digestive tract, causing, in large doses, vomiting and diarrhœa. It is a fatal narcotic poison in still larger ones, but its qualities are not well known. It is usually given, however, for intestinal worms, in decoction, or in syrup of the fresh root. Dose, 4 to 8 gm. (ʒ i. ad ʒ ij.).

Birds become stupefied by eating the berries, and fatal cases of poisoning by the seeds have occurred in India.

ALLIED PLANTS.—*Melia Indica* Brandis. *Margosa*, another Indian plant of the genus, has a bitter bark and wood. It is used as a tonic. *W. P. Bolles.*

AZORES.—The Azores or Western Islands lie about 2,000 miles from Boston, 1,400 miles from the Lizard Point, in England, and 800 from the coast of Portugal, of which they are a possession. The islands are nine in number and are divided into three distinct groups, about one hundred miles apart: Santa Maria and San Miguel forming the southeastern portion, Flores and Corvo the northwestern, and the remaining five the central division. The total area of the islands is about 1,000 square miles, and the population is estimated at 300,000. San Miguel is the largest island, being 40 miles long and 10 broad. Fayal and San Miguel are the two islands which are generally visited and with which there is the best communication. One can reach them by steamers from New York and Portugal, and possibly by sailing vessels from Boston. The whole system of islands is of volcanic origin, and their outlines in consequence are rugged and picturesque. The coast line is precipitous, and the central portion of each island rises in mountain peaks, which vary in height from 1,889 feet (San Miguel) to 7,618 feet (island of Pico). There are no natural harbors, and vessels lie in the open roadstead off the principal ports. A breakwater has been under construction for a long time at San Miguel, but it is not yet completed.

The vegetation is rich and luxuriant, and both tropical and subtropical fruits—the fig, orange, banana, loquot, pineapple, prickly pear, guava, pomegranate, and lemon—grow in the open air. Flowers bloom in nearly infinite variety, and the gardens of San Miguel and Fayal contain an almost endless diversity of tree, flower, and fruit. There are no fewer than forty plants peculiar to the islands. Besides these there are about four hundred species which are found in Europe, and three hundred and forty which are not found in Europe, but are common to Madeira, the Canary Islands, and the Azores (Roundell).

The climate is a mild and moist marine one, and very equable at all seasons of the year. The mean annual temperature is 62° F. The extremes are stated to be 86° and 45° F. The range between winter and summer is from 10° to 15°. The night temperature is generally not more than four degrees cooler than the day. The summer is enervating at 70° F., and one is drenched with perspiration on the slightest exertion. The mean temperature for winter is 58°, for spring 61°, for summer 68°, and for autumn 62° F. The three coldest months are usually January, February, and March. In winter it sometimes feels chilly and damp, and one seldom leaves home without an umbrella. The humidity is so great that wall-paper will not adhere, and the veneering of furniture strips off. The mean annual relative humidity is 76 per cent. and for winter it is 77 per cent. The mean annual rainfall is 38.5 inches. The wind blows with great force at times and there are frequent storms. "The prevailing direction of the wind in winter is from the south, southwest, and northwest, and in summer from the northeast, east, and north" (Solly, "Medical Climatology," 1897).

Ponta Delgada, in San Miguel, is the largest city of the islands. It has a population of 25,000 inhabitants. There is a good theatre, a public library, numbers of fine gardens, ancient churches and government buildings, public markets, etc. There are comfortable accommodations here as well as at Horta, the principal town of Fayal, and the food is generally good. Twenty-seven miles from Ponta Delgada by carriage road, through beautiful and wild scenery, is the Valle das Furnas, where are hot sulphur springs of a temperature of from 56° to 212° F. All contain sulphur, iron, alum, and silica in varying proportions. Besides the public bath houses, built by the Government and free to all, there are also private baths. The bath tubs are cut out of solid limestone or lava rock, and have taps for hot and cold water, the hot coming from the sulphur spring, and the cold from the water impregnated with iron. The bathing season begins in June and lasts for six months, during which time a large number of people frequent Las Furnas. The general custom is to hire lodgings and to take meals at the hotels. The various diseases for which these springs are beneficial are chronic rheumatism, which is almost invariably benefited; paralysis, syphilis, skin diseases (especially eczema), dyspepsia, and internal troubles.

Las Furnas itself is situated in the valley of the Furnas, which is the bottom of a vast crater of an extinct volcano. In this valley are the various boiling springs, with masses of white vapor hanging over them. A roaring noise is heard, as the hot gases issue from the earth. The *Caldeira Grande* supplies the sulphur water to the baths, and is enclosed by a wall some six feet in height. The water in this tank-like enclosure boils in a most furious manner and with a great noise. It furnishes nineteen gallons per minute (Roundell). The ground about is covered with patches of white sulphur and alum, streaked with orange and red. In another part of the valley is the *Boca do Inferno*, or "Mouth of Hell," a dark pit of unknown depth filled with boiling mud, constantly thrown up with a great smoke and noise. This mud is collected by the people and used as an external application in skin diseases. All the geysers or springs are said to boil most furiously when the wind is east.

So far as the climate in general of these islands is concerned it is applicable to such cases as require a mild, equable, moist climate. It is therefore suitable for patients who are suffering from neurasthenia, from Bright's disease, from nervous affections, from hay fever, etc., and for those who are convalescing from the grippe and from other acute diseases. "There is comparatively little sickness on any of the islands—very rarely any regular fevers or epidemics of any kind prevail" (Junkin). The water supply is from springs, wells, and cisterns, and is generally good.

From a personal visit to Fayal and Pico, the writer can testify to the charm and fascination of these strange islands with their ancient and primitive customs, beautiful scenery, and delightful and ever-varied walks, drives, and excursions. One can hardly conceive of a more entrancing place for the lover of nature, or one more restful and refreshing for the weary and overworked. The only drawback is the long journey there, which is almost prohibitory to a sufferer from sea-sickness.

For a very interesting and extended account of these islands the reader is referred to Mrs. Charles Roundell's "A Visit to the Azores," and also to the two papers by Canfield and Junkin on "The Azores as a Health Resort."

Edward O. Otis.

AZULE SPRINGS.—Santa Clara County, California. Location, 12 miles west of San José. These springs are not in use as a resort, but the waters are bottled and shipped in large quantities to all parts of California and even more distant points. An analysis by a chemist whose name we have been unable to secure resulted as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	86.73
Sodium carbonate	52.19
Potassium chloride	10.90

Solids.	Grains.
Potassium carbonate	2.85
Magnesium carbonate	78.16
Magnesium chloride	17.42
Calcium carbonate	10.05
Silica	3.20
Organic matter	0.18
Total	261.68

Free carbonic acid gas, 153.77 cubic inches; temperature, 59.6° F.

This is a good example of the alkaline-saline-carbonated class of waters. The analysis shows considerable resemblance to that of the Nassau Seltzer Springs in Germany. The water possesses antacid, aperient, diuretic, and tonic properties. *J. K. Crook.*

BACTERIA, PATHOGENIC, AND OTHER PATHOGENIC MICRO-ORGANISMS.

THE SCHIZOMYCETES OR BACTERIA.

These are the smallest and at the same time the most interesting of all known living organisms. While most bacteria are harmless—some of them, indeed, being of the greatest use in the economy of nature, by producing the decomposition of dead animal and vegetable matter, without which life on the earth would be impossible—others are the cause of various infectious diseases in man and animals. Bacteria are very widely distributed in nature, and are present in the air, water, soil, and also in the food and bodies of animals.

HISTORICAL REVIEW OF THE DEVELOPMENT OF BACTERIOLOGY.—Although most of the important discoveries of bacteria in their relation to disease are of comparatively recent date, from the earliest days of medicine, and long before these micro-organisms were known to exist, minute living germs were thought to be concerned in the production of many diseases. Before entering, therefore, into a detailed consideration of pathogenic bacteria, it may be interesting and instructive to review briefly the more important steps which lead up to the development of bacteriology as a science.

The first authentic observations of living micro-organisms of which there is any record are those of Athanasius Kircher, a Jesuit priest, in 1671. The compound microscope dates from 1590, but this observer was the first to find in putrid meat, milk, vinegar, cheese, etc., minute living organisms or "worms," invisible to the naked eye, which he concluded must be the cause of putrefaction. Kircher, however, did not describe the form or character of these "little worms," and with the microscopes in use in his day he probably did not see bacteria, as we now understand them. Nevertheless, his observations seemed to substantiate the view that infective diseases might be caused by substances which, introduced into the body, give rise at first to no symptoms but increase till they bring about disease: the opinion held at that time by many physicians being that if putrefaction is produced by living organisms outside the body, when these organisms are found in the blood, etc., they must necessarily cause putrefaction there also.

Not long after this, in 1675, Anthony van Leeuwenhock, a citizen of Delft, Holland, a linen draper by trade, who practised the art of grinding and polishing lenses, constructed a microscope with which he was able to observe in rain water, in putrid infusions, in human saliva, in intestinal evacuations of man and animals, and in the scrapings between the teeth, numbers of living "animalcula," as he called them, varying in form and size and in the character of their motion. Of these he gave descriptions and drawings which are remarkable for their accuracy, considering the imperfect optical instruments at his command, and there is little doubt that he really saw some of the larger species of bacteria, probably spirilla. Leeuwenhock made no attempt to assign any importance to these organisms regarding any rôle they might play in relation to disease, his work being conspicuous for its purely objective and unspeculative nature. But his contemporaries and those who immediately succeeded him seized upon the idea of these animalcules causing a great number of diseases, even in cases in which they were not found, reasoning from analogy that they must be present, until there arose a veritable craze of the germ theory of disease or *contagium animatum*. Then later followed a reaction, and the idea for a time was ridiculed out of existence. And so throughout the history of medicine this theory continued to be often asserted and as often again denied, on speculative grounds, until well into the present century, when the question was finally settled by actual observation and experiment.

Among those who at this early date (the end of the sixteenth and beginning of the seventeenth century) held to the doctrine of *contagium animatum* were Lange and Hauptmann, who shortly after Leeuwenhock's investigations advanced the opinion that puerperal fever, measles, smallpox, typhus, pleurisy, epilepsy, gout, and many other diseases were due to animal contagion. And in 1701 Andry and Linné assumed the same origin for syphilis, and Lancisi (1718) for malaria. Antonius Plenciz, a physician of Vienna, who published his deductions in 1762, maintained that not only were all infectious diseases due to micro-organisms, but that the infective material could be nothing else than living animals or plants. On these grounds he endeavored to explain the variations in the incubation period of different diseases. He insisted also that special germs were concerned in the production of each infectious disease. Plenciz believed, moreover, that these micro-organisms were capable of multiplication in the body, and suggested the possibility of their being conveyed from place to place through the air, etc. Besides these deductions he also made original investigations into the processes of putrefaction and fermentation, and having found animalcules in all decomposing material, he became so thoroughly convinced of their causative relation to these processes that he formulated the law that decomposition of animal and vegetable matter takes place only by means of and through the increase of living organisms.

Still all this was entirely a matter of speculation only, unproved by direct experiment; but the theory advanced was so plausible and the arguments used in its support were so logical and convincing, that in spite of great opposition and ridicule it continued to gain ground, and in many instances the conclusions reached by these early philosophers have since been shown to be correct.

Meanwhile the question which most attracted the interest of all investigators into the cause of infectious diseases was: What is the source of the micro-organisms which are supposed to produce these processes? Are they the result of vegetative changes in the substances in which they are found—the theory of *generatio æquivoca*, or spontaneous generation; or are they reproduced from similar pre-existing organisms—the vitalistic theory? This question is intimately connected with the investigations into the origin and nature of fermentation and putrefaction, for it was in these experiments that the theory of spontaneous generation was overthrown and the germ theory established.

Of those who most vigorously advocated the idea of *generatio æquivoca* was Needham, who, in 1749, attempted to prove experimentally the truth of his opinions. He placed a grain of barley in a watch glass containing water, covered it carefully, and allowed it to germinate. On later examination he found living micro-organisms present which he maintained were the effect, not the cause, of the decomposition and due to vegetative changes in the grain itself. Again, he boiled meat infusions and kept them in tightly corked flasks; in these also living organisms developed. As all life must have been destroyed by the boiling, and the closed flasks shut out apparently everything from without, Needham concluded that the organisms present could have been produced only from the dead material by spontaneous generation.

This conclusion seemed indeed irrefutable at the time, but Bonnet, in 1762, suggested that possibly there were certain germs which were able to resist the boiling temperature, or that the flasks were not so tightly closed that no germs could enter. Then in 1769 Lazarus and Spal-

lanzani showed experimentally the falseness of Needham's results, by demonstrating that if putrescible infusions of organic matter were placed in hermetically sealed flasks and boiled for an hour the infusions remained sterile; neither were living organisms found in the liquids, nor did they 'decompose. It was objected to these experiments that the high temperature to which the liquids were subjected so altered them that spontaneous generation could not occur. Spallanzani then simply cracked one of the flasks a little and allowed air to enter, when organisms and decomposition again appeared in the boiled solutions. Again it was objected that in excluding the oxygen of the air by hermetically sealing the flasks the essential condition for the development of putrefaction, which required the free admission of this gas, was interfered with. This objection was met by Schultze in 1836, who showed that the air could have access to sterilized infusions without causing putrefaction, if it were first freed from germs by passing it through strong sulphuric acid. Schwann effected the same thing in 1837 by passing the air through red-hot tubes; and Helmholtz in 1843 repeated and confirmed these experiments with calcined air. Again the point was raised that the heating of the air had perhaps brought about some chemical change which prevented the production of putrefaction. Schroeder and von Dusch then showed, in 1854, that if the air was filtered through cotton wool, by simply placing stoppers of this material in the mouths of the flasks before boiling—a device which has since proved of inestimable value in bacteriological work—the contained liquid was incapable of producing putrefaction. Similar results were obtained by Hoffmann in 1860, and by Chevreul and Pasteur in 1861, without a cotton filter, by drawing out the neck of the flask and bending it downward, the mouth being left open. Here the force of gravity prevents the suspended bacteria in the air from ascending, and there is no current to carry them upward into the liquid. Tyndall later (1876) showed by his investigations upon the floating substances in the air that in a closed chamber in which the air is not disturbed by currents, all suspended particles settle to the bottom, the superincumbent air being optically pure. He demonstrated beyond all doubt that the presence of living organisms in decomposing fluids was always to be explained either by the pre-existence of similar living forms in the fluid or upon the walls of the vessels containing it, or by the liquid being exposed to air which was contaminated by organisms.

But still another matter required explanation. A certain percentage of the experiments with infusions, which had been boiled for a considerable time and carefully protected from subsequent contamination, would now and then fail despite every precaution. Bonnet in 1762 had suggested the explanation of this, on the assumption that some organisms were perhaps capable of withstanding the boiling temperature, and still grow when the infusion cooled. Then Pasteur found that he could sterilize milk only at a temperature of 110° C., and later (1865) showed that the organisms which resist boiling temperature are reproductive bodies, now known as *spores*. But it was not until 1876 that the nature of spores was carefully studied and explained by Cohn, and afterward confirmed by Koch. These investigators proved that certain rod-shaped bacteria possess the power of passing into a resting or spore stage under peculiar conditions of growth, and that when in this stage they are much less susceptible to the injurious action of higher temperatures and other deleterious influences than when in their normal vegetative condition.

With this discovery the question of spontaneous generation was finally settled in the negative and the germ theory established. If living micro-organisms, some of them capable of producing the more resistant spores, were present in the air, soil, water, etc., it was easy enough to understand how irregularities occurred in previous experiments; nor could there longer be any doubt that bacteria were the cause, not the effect, of fermentation and putrefaction, and possibly also of disease.

But, in the mean time, little or nothing had been accomplished in the systematic classification of bacteria, although their forms were zealously studied microscopically as matters of curiosity. The first attempt at classification was made by Müller, of Copenhagen, in 1786, who divided micro-organisms into two main divisions—*monas* and *vibrio*. But he, like all the earlier naturalists, owing to lack of sufficiently powerful microscopes and inadequate knowledge of the biology of bacteria, fell into grave errors of classification. Thus various motile organisms, which are now recognized to be of vegetable origin, were commonly included among the infusorians or unicellular animal organisms. Even Ehrenberg, in 1838, and Dujardin, in 1841, though their work shows considerable progress in this direction, failed to arrive at a satisfactory classification of bacteria; these authors dividing bacteria into four orders—*bacterium*, *vibrio*, *spirillum*, and *spirochaëte*—and including them with the infusorians. Perty, in 1852, was the first apparently to draw attention to the vegetable origin of bacteria; and Robin, in 1853, then suggested their relationship to the algæ. But it remained for Cohn in 1854, and Naegeli in 1857, to bring anything like system into the confusion which had previously existed regarding the classification of bacteria. It was Naegeli who established their resemblance to the fungi, in that they were chlorophyll-free plants, and gave them the name of *schizomycetes* or fission fungi to indicate their mode of reproduction; and Cohn confirmed and emphasized this relation of bacterial species to the vegetable kingdom, and first employed the term *bacteria* for the entire class of these micro-organisms, studying their various groups more carefully.

At the same time, the physiological properties of bacteria were studied, with as much, if not more, success than their morphology and classification. Stimulated by the discovery of the microbic origin of the processes of fermentation and putrefaction,—the specific cause of one form of which, alcoholic fermentation, was found by Latour and Schwann, in 1837, to be the yeast plant (*saccharomyces cerevisiæ*)—the study of the causal relation of micro-organisms to disease was again taken up with renewed vigor. So far the bacterial source of infectious diseases was founded only on hypothesis, and although belief in this theory was much strengthened by the foregoing experiments, it had not yet been proved. It was not long, however, before the necessary proof was forthcoming at least for one disease, for in the same year as Schwann's discovery of the yeast plant, Bassi discovered that a fatal infectious malady of silkworms was due to a parasitic micro-organism; and later a similar origin was found for various infectious diseases in grains, potatoes, etc. Just about this time, too (1840), Henle published his "Pathological Investigations," in which he described the relation of bacteria to disease with remarkable clearness and precision, the weight of the opinion of this great authority contributing much to arouse interest in the doctrine of infection. Although Henle failed to find organisms in the tissues in various infectious diseases, this did not lead him to change his opinion, for he contended rightly that there were no means at that time of distinguishing between tissue cells and bacteria. Nor did he consider the presence of micro-organisms alone sufficient proof of their etiological relation, but postulated the conditions later confirmed to the letter by Koch, which must be fulfilled to demonstrate that a disease is due to a specific micro-organism. These conditions were constant presence in the disease, isolation, and evidence of the infectious nature of the isolated germ by inoculation. Similar conclusions were also reached by Mitchell, independently, reasoning by deduction.

Very soon after this it was shown experimentally that micro-organisms were the cause of various skin diseases in man, as favus and ringworm. About this time also, Pollender (1849) observed certain rod-shaped bacteria in the blood of animals dying from anthrax or splenic fever, and he was followed by Davaine (1850); but these observers attached no special significance to their discovery until Pasteur made public his researches in regard to

fermentation and the rôle played by bacteria in the economy of nature. Then Davaine resumed his studies, and in 1863 established by inoculation experiments the bacterial origin of anthrax,—which was later confirmed by Pasteur, Koch, and others.

Schwann had already shown the connection between certain organisms and alcoholic fermentation, but Pasteur, in 1857, deserves the credit of finally establishing the fact that the various kinds of fermentation,—lactic acid, butyric acid, acetic acid fermentation, etc.—are all caused by micro-organisms, which not only differ in physiological action, but are characterized by morphological and biological peculiarities. In this connection Pasteur also made the discovery of certain bacteria which were incapable of growth in free oxygen, assigning to them the name of *anaërobes* to distinguish them from the *aërobes*, or those requiring the presence of free oxygen. Others, again, he found were capable of growth, either with or without free oxygen, and these he called *facultative anaërobes*. Pasteur's investigations demonstrated the fact that since bacteria are the cause of fermentation and putrefaction, they are necessary for the life of plants and animals, for without their agency the higher plants, incapable of feeding upon the complex substances of dead animals and plants, would die if these substances did not undergo decomposition into their elements through the instrumentality of bacteria; and thus the earth would be uninhabitable.

The next important discoveries related to the cause of infection in wounds. Lemaire, following up the experiments of Pasteur, had observed that when carbolic acid was added to putrescible substances fermentation was prevented, and he came to the conclusion that the carbolic acid destroyed the germs which produced fermentation. The processes of fermentation and suppuration he believed to be analogous. If the addition of carbolic acid solution inhibited fermentation, why should it not be applicable to the prevention of suppuration in wounds?

Upon these suggestions Lister now (1868–70) instituted his famous antiseptic treatment of wounds, which has led to such brilliant results in modern operative surgery. The publication of Lister's work exerted a powerful influence upon the general recognition of the germ theory of infectious diseases, and had much to do in lessening the number of its opponents. Then Rindfleisch, in 1866, and Waldeyer and von Recklinghausen, in 1871, drew attention to the constant occurrence of micro organisms in pyæmic processes resulting from wound infection,—observations which have since been amply corroborated by others for all suppurative processes under whatever condition produced.

From this time on followed, in comparatively rapid succession, the discoveries of a number of micro-organisms as the cause of various infectious diseases. In 1873, Obermeier announced having found in the blood of patients suffering from relapsing fever a minute spiral, motile organism—the *spirochæte Obermeieri*—which is now recognized as the specific infective agent in this disease. In 1878, Koch published his important work on traumatic diseases. In 1879, Hansen reported the discovery of bacilli in the cells of leprous tubercles, which, from subsequent investigations, are believed to be the cause of leprosy. Neisser, in the same year (1879), discovered the "gonococcus" in gonorrhœal pus. In 1880, Eberth and Koch, independently, observed the typhoid bacillus, which Gaffky, in 1884, proved to be the cause of typhoid fever. In the same year Pasteur published his discovery of the bacillus of fowl cholera and his investigations upon protective inoculation against this disease and anthrax. Sternberg and Pasteur, also in the same year, independently observed a pathogenic micro organism in human saliva, which was subsequently (1885) proved by Fraenkel and others to be the organisms most commonly associated with acute lobar pneumonia and now recognized as the usual cause of that disease—the *diplococcus pneumoniæ*. In 1881, Koch made his fundamental researches upon pathogenic bacteria, which form the basis of our modern bacteriology. He introduced solid culture media and the "plate method" for obtaining pure cultures, and showed how different organisms could be isolated, cultivated artificially, and by inoculation of pure cultures into susceptible animals made, in many cases, to reproduce the specific disease of which they were the cause—thus carrying out Henle's suggestions. It was also in the course of this work that the Abbé system of substage condensing apparatus on the microscope, and the Ehrlich-Weigert method of staining bacteria for microscopical preparations were first generally used. In 1882, Koch published the discovery of the tubercle bacillus. The same year Pasteur made his investigations upon hog erysipelas; in this year also his communication upon rabies appeared. In 1882 also Loeffler and Schütz discovered the bacillus of glanders. In 1884 Koch discovered the spirillum of Asiatic cholera or "comma bacillus." This year, too, Klebs and Loeffler discovered the diphtheria bacillus. Rosenbach also, by the application of Koch's methods, fixed definitely the characters of the various pus-producing organisms. And the same year Nicolaier discovered the tetanus bacillus which Carl and Rattone afterward showed to be the true cause of the disease, and Kitasato obtained in pure culture. In 1892, Pfeiffer discovered the bacillus of influenza; and finally, in 1894, Kitasato discovered the bacillus of bubonic plague.

This closes our brief historical sketch of the development of bacteriology, including all the more important facts which are of special interest to physicians. But no review of the progress which has been made in this branch of science would be complete without reference to the recent discoveries of antitoxins in the treatment of diphtheria and tetanus, the protective inoculations against rabies, cholera, the plague, etc., and the peculiar reactions of the blood serum of persons ill with infectious diseases. These discoveries, in which the names of Pasteur, Koch, Behring, Kitasato, Roux, Pfeiffer, Gruber, and Widal are the most prominent, not only mark an epoch in the history of bacteriology in relation to medicine, but they have served to establish beyond all doubt the microbic origin of many diseases, the cause of which was until then in dispute. Attention has, moreover, been directed of late to the smaller group of animal parasites, the protozoa—to which class belong the plasmodium malariæ and the amœba coli, the cause of malaria and epidemic dysentery, respectively—which may prove to be the source of infection in many affections the origin of which is still unknown, as the exanthemata. And quite recently interest has been awakened in the possible pathogenic properties of certain of the fungi, among which it is suggested may be found the cause of other unexplainable diseases, as cancer and rabies. Several bacteria also not mentioned in this list have created considerable discussion of late, as the "bacillus icteroides" in yellow fever, and a small bacillus found in whooping-cough; but these organisms have not yet been positively shown to be the specific cause of the diseases with which they are found associated, and hence have been omitted.

General Characteristics of Bacteria.—*Classification and Definition.*—Under the general term "micro-organism" may be included all the minute lower forms of life which are of biological or hygienic interest, and which are the cause of fermentation, putrefaction, and disease. They are both of the vegetable and the animal kingdom; among the latter of these are the *protozoa*, and among the former the *fungi* and *bacteria*. Bacteria are classed among plants from the fact that they are able to derive their nourishment both from organic and inorganic materials. They are of the class of *cryptogamous plants*, that is, plants which, having no seeds or flowers, are reproduced by means of spores, such as the fungi, lichens, and algæ. Of these they are most nearly allied to the algæ, but differ from them in that they are without *chlorophyll*, the green coloring matter by means of which the higher plants, under the influence of sunlight, decompose carbon dioxide, ammonia, and sulphuretted hydrogen into their elementary constituents. In many respects bacteria resemble the mycetes or fungi, which are also without

chlorophyll; but they differ from these again in their mode of reproduction, being reproduced by division or simple fission. Hence bacteria have been called *schizomycetes* or fission fungi. A few varieties of unicellular organisms have also been found resembling bacteria in all points, except that they possess chlorophyll or some pigment substance similar to it. Other organisms, again, have been observed which, though they are without chlorophyll, are able to build up organic compounds synthetically and even in the absence of light. Some bacteria, moreover, especially the motile forms, are closely allied to certain micro-organisms belonging to the animal kingdom. It is therefore difficult to classify or define bacteria scientifically, under our existing knowledge of them. Excluding the micro-organisms, however, which contain chlorophyll, bacteria may be defined accurately enough for all practical purposes as *extremely minute living vegetable organisms, without chlorophyll, which are reproduced by division, consisting of single spherical, rod-shaped, or corkscrew-like cells or aggregation of such cells, between whose protoplasm and nucleus it has not been possible to differentiate with certainty.*

Bacteria, then, belong to the family of mycetes or fungi, of which there are four groups:

1. *Hyphomycetes*, or *mould fungi.*
2. *Blastomycetes*, or *yeast fungi.*
3. *Streptothrices.*
4. *Schizomycetes* or *bacteria.*

But besides this classification of bacteria it becomes necessary to divide them into *saprophytes* or refuse-eaters, and *parasites*. Saprophytic micro organisms are such as commonly exist independently of a living host, obtaining their supply of nutriment from soluble food stuffs in dead organic matter. Parasitic micro-organisms, on the contrary, live on or in some other living organism, from which they derive their nourishment for the whole or a part of their existence. Those micro-organisms which depend entirely upon a living host for their existence are known as *strict* or *obligatory parasites;* those which can lead a saprophytic existence, but also thrive within the body of a living animal, are called *facultative parasites.* The saprophytes strictly so called, which represent the larger number of micro-organisms, are not only harmless but perform the useful function of the destruction of dead organic matter through fermentation and putrefaction. The parasites, on the other hand, though some of them may multiply in the secretions or on the surface of the body without injury to the animal upon which they exist, are usually harmful invaders, giving rise, through the lesions brought about in the body by their growth and products, to various acute and chronic infectious diseases.

Numerous attempts have been made by various authors to classify bacteria systematically, but usually with the proviso that the system was only a temporary one. As a rule, the genera are based upon morphological characters and the species upon biochemical, physiological, or pathogenic properties. While the form, size, and method of division are the most permanent characteristics of micro-organisms, and so are naturally utilized for classifications, nevertheless on this basis of arrangement there are decided difficulties. Thus while the form and size of bacteria are fairly constant under the same conditions, they are in many quite different under diverse conditions. Another serious drawback is that these morphological characteristics give no indication whatever of the relation of bacteria to disease, etc.—the very characteristics for which as physicians we study them. Other properties of bacteria which are fairly constant under uniform conditions are those of spore formation, motility, reaction to staining agents, relation to temperature, to oxygen or other food materials, and finally their relation to disease, fermentation, and pigmentation (pathogenic, zymogenic, and chromogenic bacteria).

Taking any one of these properties of bacteria as a basis, we can classify them; but even here there will be groups which under certain conditions would be placed in one class and under other conditions in another. Thus the power to produce spores may be totally lost or held in abeyance for a time. The relation to oxygen may be gradually altered, so that an anaërobic species grows in the presence of oxygen. Parasitic bacteria may be so cultivated as to become saprophytic varieties, and those which have no power to grow in the living body given pathogenic properties. The possibility of making any thoroughly satisfactory classification is rendered still more difficult by the fact that many necessarily imperfect attempts have already been made, so that there is a great deal of confusion, which is steadily increased as new varieties are found or old ones re-investigated and classified differently in the various systems. We shall, therefore, simply use the commonly accepted nomenclature, without any attempt at classification, except to consider together as far as practicable certain groups of bacteria whose members are closely allied to one another in some one or more important features.

Morphology.—There are three basic forms of the individual bacterial cells: the sphere, the rod, and the segment of a spiral. Although under different conditions the form of any one species may vary considerably, yet these three main divisions under similar conditions are permanent; and so far as we know, it is never possible by any means to bring about changes in the organisms that will result in the conversion of the morphology of the members of one group into that of another,—that is, cocci always, under suitable conditions, produce cocci, bacilli produce bacilli, and spirilla produce spirilla.

The form of the bacterial cells at their stage of complete development must be distinguished from that which they possess just after or before they have divided. As the spherical cell develops preparatory to its division into two cells, it becomes elongated and appears as a short oval rod at the moment of its division; on the contrary, the transverse diameter of each of its two halves is greater than their long diameter. A short rod becomes in the same way, at the moment of its division, two cells, the long diameter of each of which may be even a trifle less than its short diameter, and thus they appear on superficial examination as spheres.

As bacteria multiply the cells produced from the parent cell have a greater or less tendency to remain attached. In some varieties this tendency is extremely marked, in others it is slight. This union may appear simply as an aggregation of separate bacteria or so close that the group presents the appearance of a single cell. According to the method of the cell division and the tenacity with which the cells hold together we get different groupings of bacteria, which aid us in their identification and differentiation. Thus whether the bacterial cell divides in one, two, or three planes, we get forms built in one, two, or three dimensions. If we group bacteria according to the characteristic forms of the cells, and then subdivide according to the manner of their division in reproduction and the tenacity with which the newly developed cells cling to one another, we shall have the following varieties:

1. *Coccus or Micrococcus.*—Spherical or subspherical forms.

(*a*) *Single coccus*, grouped irregularly.

(*b*) *Diplococcus*, forming pairs.

(*c*) *Streptococcus*, forming chains, often showing paired cocci.

(*d*) *Tetracoccus*, forming fours by division through two planes of space.

(*e*) *Sarcina*, forming packets of eight by division through three planes of space.

(*f*) *Staphylococcus*, forming irregularly shaped, grape-like bunches by division apparently in any axis.

2. *Bacillus.*—Oblong or cylindrical forms, having one dimension greater than any other, more or less straight and never forming spirals, dividing only in one plane perpendicular to its long axis.

(*a*) *Single bacillus.*

(*b*) *Diplobacillus* and *streptobacillus*, forming twos or longer chains, the bacilli attached end to end.

(*c*) *Filaments* or thread-like growths, in which division into bacilli of the normal length are not apparent,

occur irregularly and transversely to the long axis of the growth.

8. *Spirillum.*—Cylindrical and curved forms, constituting complete spirals or portions of spirals. Spirilla, like bacilli, divide only in one direction. A single cell, a pair, or the union of two or more elements may thus present the appearance of a short segment of a spiral or a comma-shaped form, an S-shaped form, or a complete spiral or corkscrew-like form.

The term *bacterium* has also been used by some authors for *bacilli* or rod-shaped organisms; while to *spirilla* the terms *vibrio* and *spirochaëte* have sometimes been applied. But as there is no uniformity among bacteriologists as to the exact meaning of these terms, we shall employ only the terms *bacillus* and *spirillum* to denote these different groups.

Structure of Bacterial Cells.—A bacterial cell consists of protoplasm enveloped in a cell membrane; the cells as a rule being homogeneous and without visible nucleus. The cell is generally colorless, though in some species it contains chlorophyll or other similar coloring matter. The protoplasm may at times also contain minute granules of sulphur and occasionally refractive oily particles or colorless spaces in stained specimens, which have been mistaken for spores, but are supposed to be due to the shrinkage of the protoplasm with partial dissolution of the cell wall caused by abstraction of water, known as *plasmolysis*. In many species of bacteria, as in the diphtheria bacillus, there is observed in the interior of the cells, on suitable staining, a peculiar granular appearance, to which has been given the names *metachromatic bodies* or *sporogenous granules*. The cell membrane is sometimes colored, and sometimes surrounded by a gelatinous envelope or capsule, which can be occasionally brought out by staining. The demonstration of this capsule may be of assistance in differentiating between certain bacteria, as, for example, some forms of the streptococcus and pneumococcus. A peculiarity of the capsule bacteria is that, except very rarely, they exhibit this envelope only when grown in the animal body or in special culture media, such as liquid blood serum, bronchial mucus, etc. The outer surface of bacteria when occurring in the form of spheres and short rods is almost always smooth and devoid of appendages; but the larger rods and spirals are usually provided with fine hair-like cilia or *flagella*, which are their organs of motility. These flagella, either singly or in numbers, are sometimes distributed over the entire body of the cell, or they may form a tuft at one end of the rod, or only one polar flagellum is found. The polar flagella appear in the cells shortly before division. They are believed to be formed of protoplasmic material, which penetrates the cell membrane, and probably to have the property of protrusion and retraction; but their nature is imperfectly understood. So far as we know, the flagella are the only means of locomotion of bacteria. They are not readily stained, special mordants being required for this purpose. Bacteria may lose their power of producing flagella for several generations, whether permanently or not is not known.

Vegetative Reproduction.—The process of vegetative reproduction of bacteria, which is to be distinguished from spore formation, takes place by division, and may go on, under favorable conditions, indefinitely. When development is in progress a single cell will be seen to elongate in one direction. Over the centre of the long axis thus formed there appears a slight indentation in the outer envelope of the cell; this indentation increases until there exist two distinct cells. As a rule, the cells separate soon after division, but occasionally they remain together for a time, forming pairs and chains, or under certain conditions of nutrition long threads or filaments, which break up into fragments, however, when placed under other conditions. Although elongation in one direction and transverse division is the rule for most bacteria, there are certain groups (as the sarcina, for example) which divide more or less regularly in three directions. Division in two directions results, as already mentioned, in the formation of tetrads; while division irregularly in all directions produces grape-like clusters. Bacilli and spirilla, as far as we know, never divide longitudinally.

Spore Formation.—This is the process by which bacteria are enabled to enter a stage in which they resist deleterious influences to a much higher degree than is possible for them in the growing or vegetative condition. It is not a process of multiplication of bacteria, but only one of reproduction for the preservation of the species under conditions unfavorable to their growth, and occurs when the organism has nearly exhausted its supply of nutrition or poisoned it with products of its growth, etc. The fungi, on the other hand, form spores under the most favorable conditions, even requiring an abundant supply of nutrition for their production, the life history of the fungi, indeed, being incomplete without the formation spores. But in bacteria the process is comparatively rare, and all the conditions which tend to bring it about are not yet known.

Two kinds of spores have been described in bacteria:

1. *Endospores*, which are strongly refractile and glistening in appearance, oval or round in shape, and developed within the interior of the cell. They are characterized by the power of resisting to a considerable extent the injurious influences of heat, desiccation, and chemical disinfectants, which would kill vegetative cells. 2. *Arthrospores* or jointed spores, developed, not within the cell, but as a sprout-like projection from one of its extremities. These jointed bodies are believed by Hueppe to have also more or less greater power of resistance to desiccation, etc., than the ordinary cells, though less than endospores; but they have been but little studied, and their existence in bacteria is still an open question. In describing the biological characters, therefore, of the various species, whenever their property of spore formation is mentioned it will be understood that endogenous spores are meant.

The production of endospores in the different bacterial species, though not identical, is very similar. Spores represent a state of suspended activity, and motile organisms always come to a state of rest or immobility previous to spore formation. The following description of the method of spore formation in the anthrax bacillus may serve as an illustration of the process: Under suitable conditions of temperature, moisture, etc., the cell is elongated and at first the protoplasm is clear and homogeneous, but after a time it becomes turbid and finely granular. These fine granules are then replaced by a smaller number of coarser granules, which are finally amalgamated into a spherical or ovoid refractile body. This is the spore. As soon as the process is completed there appears between two spores a delicate partition wall. For a time the spores are retained in a linear position by the cell membrane of the rod, but this later is dissolved or disintegrated and the spores are set free.

The following types have been observed: (*a*) Spores lying in the interior of a short, undistended cell; (*b*) spores lying in the interior of a short, undistended cell, forming one of the elements of a long filament; (*c*) the spores lying at the extremity of an undistended cell much enlarged at that end—the so-called "head spores"; and (*d*) the spores lying in the interior of a much enlarged cell in its central portion, giving it a spindle shape.

The *germination of spores* takes place as follows: By the absorption of water the spores become swollen and paler in color, losing their shining, refractile appearance. Later a little protuberance is seen to project from one side or at the extremity of the spore; this rapidly grows out to form a new rod, which consists of soft protoplasm enclosed in a membrane formed of the inner layer of the cellular envelope, or *endosporum*. The outer envelope, or *exosporum*, is then cast off, and may often be seen in the vicinity of the newly formed rod. In some species the vegetative cell emerges from one end of the oval spore, and in other species the exosporum is ruptured and the bacillus emerges from the side.

Involution Forms.—In old cultures of bacteria in which deleterious substances have been produced or the supply of nutriment has been exhausted, there are frequently

found irregular or distorted forms, which are thought to be due to abnormal development of the bacterial cells under unfavorable conditions. These are generally spoken of as *involution* or *degenerated* forms, though sometimes the terms *pleomorphism* and *polymorphism* are applied to them. Placed under suitable conditions these irregular or deformed cells again produce normally shaped organisms.

Chemical Composition.—Qualitatively considered bacterial cells consist of carbon, hydrogen, oxygen, and nitrogen, for the most part in the form of water, salts, fats, and albuminous substances. There are also present, in smaller quantities, extractive substances soluble in alcohol. Glucose has not been found in any bacteria, but many species contain starchy substances which give a reaction with iodine. Cellulose has also been detected in certain species, as the bacillus subtilis, some of the colon group, and the tubercle bacillus. The neuclein bases, xanthin, guanin, and adenin, moreover, have been found in considerable amounts. There is also a group of bacteria, the *Beggiatoa*, which contain sulphur, and another group, the *Cladothrix*, has the power of separating ferric oxide from water containing iron, as in iron and sulphur springs. But very little is known about the chemical composition of bacteria quantitatively, only few species having been completely analyzed; but the percentage composition would appear to depend largely upon the character and constituents of the culture media in which they are grown.

Conditions of Growth.—Although there are some pathogenic bacteria which grow only in the bodies of living animals and plants, and are therefore apparently strict parasites, yet the majority of pathogenic micro-organisms can be cultivated more or less readily in artificial culture media, and are thus facultative parasites. The saprophytic bacteria, as a rule, are easily cultivated artificially, though some of these, as certain organisms met with in the saliva and in water, are very difficult or impossible to cultivate.

The essential condition for the cultivation of all bacteria is water; salts are also indispensable, and organic matter for the supply of carbon and nitrogen. Most of the important bacteria and all the pathogenic species thrive best in media containing albumin and of a neutral or slightly alkaline reaction. The demands of bacteria, however, with regard to nutrition are various. Some water bacteria, for instance, require so little organic food that they will grow in water that has been twice distilled, and in which no nutritive material can be chemically demonstrated. But the pathogenic bacteria are seldom so easily satisfied, though there are several species which will develop in comparatively simple culture media and without albumin.

Considering more in detail the source of the important chemical ingredients of bacteria, we find that their nitrogen is most readily obtained from diffusible albuminous material and less easily from ammonium compounds. Their carbon they derive from carbohydrates, albumin, peptone, sugars, glycerin, fats, and other organic substances. Some bacteria grow best in special culture media, such as bouillon, gelatin, agar, blood serum, potato, milk, etc. The majority of bacteria absolutely require the presence of free oxygen for their growth, although a considerable number fail to develop at all unless oxygen be excluded. Between these two groups of aërobic and anaërobic bacteria, we have those which grow either with or without oxygen. Some of the strictly anaërobic species require for their full development the presence of fermentible substances, such as sugars, from which they obtain their oxygen. In so far as the amount of oxygen present acts unfavorably upon bacteria, there will be more or less restriction in certain of their life processes, such as pigment and toxin production, spore formation, etc. Some aërobic bacteria, however, can be accustomed to grow without oxygen, while certain of the anaërobes can be gradually made to develop in its presence. Among other food stuffs required by bacteria are sulphur and phosphorus; calcium or magnesium and sodium or potassium are also usually needed. Very few species require iron.

With regard to the more complex culture media, whether naturally existing, such as blood serum, ascitic fluid, etc., or artificially made, as bouillon, glycerin, and agar, beyond the necessary amount of soluble nutrition present, the points of greatest importance are the relative proportion of each form of food and its total concentration. Very wide differences, however, may exist in the composition of the culture media with but slight effect upon the development of bacteria, the growth usually ceasing on account of the accumulation of deleterious substances in the media rather than from exhaustion of the food supply.

The reaction of culture media is of great importance. Most bacteria grow best in neutral or slightly alkaline media, very few requiring an acid medium, and none of the parasitic species. An amount of acid or alkali insufficient to prevent the development of bacteria may yet suffice to rob them of some of their most important functions, as the production of toxins.

The influence of one species of bacteria upon the growth of another, either when cultivated together or following one another, is very noticeable. The development of one species of bacteria in a medium causes that substance usually to become less suitable for the growth of other bacteria. This is due partly to the impoverishment of the medium, but also to the production of chemical substances or enzymes which are antagonistic not only to the growth of the bacteria producing them, but to many other species; very rarely are the changes produced by one species of bacteria in the media favorable to some other species.

A suitable temperature is also essential for the growth of bacteria. The most favorable or optimum temperature varies for different species, but for any bacteria a range of about 2.5° C. above or below the optimum covers the limits of their most vigorous growth. Few bacteria grow well under 10° C. or over 40° C.; 2° C. is about the lowest temperature at which any bacterial species has been known to grow, and 70° C. is the highest. In many cases the temperature of the natural medium in which the bacteria have been deposited is the controlling factor in deciding the temperature at which they will or will not grow under artificial conditions. Thus nearly all parasitic bacteria require a temperature near that of the body (36°–38° C.) for their development, while many saprophytic bacteria can grow only at much lower temperature. Bacteria when exposed to lower temperature than suffices for their growth, while having their activity inhibited, are not otherwise injured; but exposure to a higher temperature than that which permits growth destroys the life of bacteria.

VITAL PHENOMENA OF BACTERIA.—*Motility.*—Many bacteria when examined in the hanging drop are seen to exhibit active movements. This motility is produced by the fine hair-like *flagella* attached to all motile species. The movements are various—creeping, rotary, undulatory, etc., at one time being slow and sluggish and at another so rapid that no detailed observation is possible. The spontaneous movements of bacteria are to be distinguished from the so-called *Brownian* or molecular movements, which is a dancing, trembling, stationary motion possessed by all finely divided organic particles. Not all species of bacteria, however, which have flagella exhibit spontaneous motility invariably; in certain culture media and at too low or too high temperatures, and when there is an insufficient or excessive supply of oxygen, motility may be absent. The property of motility, therefore, evidently depends upon other factors than flagella. Some chemical substances apparently exert a peculiar attraction for bacteria, known as *positive chemotaxis*, while others repel them, *negative chemotaxis*; not all varieties, however, are affected alike, for the same substances may exert on some bacteria an attraction and on others a repulsion. Oxygen, for example, attracts aërobic and repels anaërobic species, and for each different species there is a definite amount of oxygen which

most strongly attracts or repels. Possibly these chemotaxic properties, which are as yet but little understood, may, under certain conditions, have something to do with the motility of bacteria, independently of their organs of locomotion, the flagella.

Production of Light.—Some bacteria have the property of emitting light; these are quite widely distributed in nature, particularly in sea water, salt fish, etc. The emission of light or phosphorescence is a property of the living protoplasm of bacteria, and is not usually due to the oxidation of any photogenic substance produced by them. Anything which is injurious to the life of the organism affects this property, as too cold or too high a temperature, chloroform, etc. But while the organism is unable to emit light except during life, it can live, as in an atmosphere of CO_2, without exerting this property. The power of phosphorescence is soon lost, unless the organism is constantly transplanted to fresh media, the presence of oxygen, carbon, and nitrogen being usually required to preserve the property.

Thermic Effects.—Most bacteria possess the power of producing heat, although this does not ordinarily attract attention because of the slight amount of heat produced in cultures. Careful tests, however, have shown that heat is produced. The increase of temperature in organic substances when stored in a moist condition, as tobacco, hay, manure, etc., is partly, at least, due to the action of bacteria. The high temperature thus exhibited may be caused, as Rabinowitsch suggests, to the so-called thermophilic bacteria.

Chemical Effects.—The processes which substances undergo in being decomposed depend, first, on the chemical composition of the substances involved and the conditions under which they exist, and, secondly, on the action of bacteria present. Bacteria are able to construct their body substance out of various kinds of nutritive materials and also to produce fermentative products and poisons, and they can do these things either analytically or synthetically with almost equal facility. In the chemical building up of their cell substance we may distinguish several groups of phenomena: polymerization, a sort of doubling up of a simple compound; synthesis, a union of different kinds of simple substances into one or more complex compounds; formation of anhydrides, by which new substances arise from a compound through loss of water; and reduction or loss of oxygen, which is brought about especially by the entrance of hydrogen into the molecule. The breaking down of organic bodies of complicated molecular structure into simpler combinations takes place, on the other hand, through the loosening of the bands of polymerization, by hydration or entrance of water into the molecule, or by oxidation.

The chemical effects of bacteria are greatly influenced by the presence or absence of free oxygen. The access of pure atmospheric oxygen makes the life process of most bacteria more easy, but it is not indispensable when available substances are present which can be broken up with sufficient ease. Life processes carried on without oxygen do not effect any profound molecular changes in the organic material which is decomposed; but in order that the living organism may obtain the requisite amount of energy from this mode of life, a proportionately large quantity of material must be decomposed. Therein lies the power of a small amount of ferment to produce much alcohol or lactic acid, and of parasites which have invaded the living body to generate intensely poisonous substances out of the body proteids. In the presence of oxygen the decomposition products formed by the action of anaërobic bacteria are further decomposed and oxidized by the aërobes, being thus rendered inert, as a rule, and consequently harmless. Some bacteria have adapted themselves to the use of oxygen compounds, from which they are able to obtain their oxygen; and others—the obligatory or strict anaërobes—are able to live only in the presence of oxygen. The facts of anaërobiosis are of great importance to technical biology and pathology. Under strictly anaërobic conditions, secondary oxidation of the products of decomposition being impossible, the latter accumulate without the formation of by-products. Thus parasitic bacteria are often found to produce far more poison in the absence than in the presence of air.

Fermentation; the Production of Organized and Unorganized Ferments.—The chemical effects of bacteria are largely dependent upon the composition of the culture media. Thus many species which in albuminous media produce no visible changes, when sugar is added give rise to fermentation with the formation of gas. The term fermentation is differently applied by different authors. Some call every kind of decomposition due to bacteria a fermentation; others limit the term to the process when accompanied by the visible production of gas; while others again take fermentation to mean only the decomposition of carbohydrates, with or without gas production. Fermentation may be properly defined as a chemical decomposition of an organic compound, induced by living organisms or substances contained within them (organized ferments), or by chemical substances thrown off from the bacteria (unorganized ferments). In the first the action is due to the growth of the organisms producing the ferments, as in the formation of acetic acid from alcohol by the action of the vinegar plant, and in the second the enzyme causes a structural change without losing its identity, as in digestion. These ferments or enzymes, even when present in the most minute quantities, have the power of splitting up or decomposing complex organic compounds into simpler, more easily soluble or diffusible molecules. Ferments, like albuminoids, are not dialyzable. They withstand dry heat, but are destroyed in watery solution by a temperature of over 70° C. They are injured by acids, especially mineral acids, but are resistant to alkalies. All fermentation has for its object the acquisition by the organism of a store of energy. This storing up of energy is acquired in either of the ways above mentioned. The commonest example of fermentation by decomposition is that of sugar into alcohol and carbonic acid. Exactly opposite to this, and far less common, is fermentation by oxidation, as in the production of acetic acid from alcohol. Proteolytic or peptonizing ferments, which are similar to pepsin and trypsin, in that they decompose insoluble albuminoids into soluble or digestible substances, are very widely distributed. The liquefaction of gelatin, produced by many species of bacteria, is due to the presence of these peptonizing ferments. Diastatic ferments, which convert starch into sugar, like ptyalin, are also produced by bacteria. Other bacterial ferments are the invertive ferments, or those which convert cane sugar into grape sugar; and the rennet ferments having the power of coagulating milk.

The process of fermentation also gives rise to products that are destructive to the ferments; hence fermentation ceases when the nutriment is exhausted. Different kinds of fermentation are called by different names according to the products they yield. Thus, acetic acid fermentation, alcoholic or vinous fermentation, lactic acid fermentation, butyric acid fermentation, etc., are produced by different species of bacteria.

Putrefaction.—By putrefaction in the common acceptation of the term is understood the decomposition of animal or vegetable matter, accompanied by the generation of fetid odors. Scientifically considered it is a kind of fermentation or the decomposition of complex organic compounds, albuminous substances and the like, into simpler combinations, produced by micro-organisms called putrefactive ferments. Typical putrefaction occurs only when oxygen is absent or scanty. As putrefactive products we have peptone, ammonia, and the amines—leucin, tyrosin, and other amido-substances; oxyfatty acids, indol, skatol, phenol; and finally sulphuretted hydrogen, mercaptan, carbon dioxide, hydrogen, and possibly marsh gas.

Pigment Production.—Various bacteria form characteristic pigments as products of their growth. Some of these have been isolated and have been found to possess many of the properties of the aniline dyes. They have no known importance in connection with disease, but are

of interest and value in identifying certain species of bacteria. The principal pigments produced by chromogenic bacteria which have been chemically studied are: red, yellow, violet, blue, and green pigments. All conditions which are unfavorable to the growth of the bacteria decrease their power of pigment production, as cultivation in unsuitable media or too low or too high a temperature, etc.

Alkaline Products and the Decomposition of Urea.—Aërobic bacteria sometimes produce alkaline products from albuminous substances in culture media free from sugar. Most species produce acids in the presence of sugar, neutral or slightly alkaline cultures thus often becoming acid at first, owing to the small quantity of sugar contained in the meat used for making nutrient media; and later when the sugar is exhausted they become alkaline again. The substances producing the alkalinity of cultures are chiefly ammonia, the amines, and the ammonium salts. The conversion of urea into carbonate of ammonia is due to the action of bacteria. Several organisms also have been isolated which separate ammonia from urea.

Ptomaïns and Toxins.—Brieger has recognized a number of complex alkaloids, closely resembling those found in ordinary plants, which are the products of bacterial growth; and these alkaloids he has named *ptomaïns* (from πτῶμα, a cadaver), because obtained from putrefying or dead bodies. Nencke, and later Brieger, Vaughan, and others, have succeeded in preparing organic bases of definite chemical composition out of putrefying fluids,—meat, fish, old cheese, milk, etc., as well as from pure cultures of bacteria. Some of these were found to exert a poisonous effect, and for a long time were looked upon as the specific bacterial poison, while others were harmless. The poisons are particularly interesting, as they may be present in the putrefying cadaver, and hence must be taken into consideration in medico-legal questions. They may also be formed in the living body, and if not rendered innocuous by oxidation may come to act therein as self-poisons or *leucomaïns*. Recent investigations have shown that these are not the substances to which are due the specific toxic effects of bacteria, which are designated *toxins* and have quite different characteristics.

The best-known ptomaïns are: *Collidin* from putrefying meat or gelatin, *cadaverin* from decomposing dead bodies; *neurin* and *muscarin*. The first two of these contain no oxygen, and are non-poisonous, while the last two ptomaïns contain oxygen and have a poisonous action the opposite of atropine. *Tyrotoxicon*, a ptomaïn decomposing milk, and found by Vaughan in poisonous cheese, is apparently derived from butyric acid. *Pyocyanin*, which produces the color of blue and green pus, is a ptomaïn pigment. Similar bodies may also be found in the intestinal contents as products of bacterial decomposition. Some of them are poisonous and can be absorbed into the body, where they play the part of self-poisons or leucomaïns; and it has been thought that the symptoms designated as coma and tetany may be ascribed to the absorption of substances of this nature. The name ptomaïn was formerly, and is still by some authors, applied to all bacterial poisons, as in cases of so-called food poisoning due to decomposing meat, sausage, cheese, or milk. But instead of ptomaïns, which are now commonly understood to include only the crystalline products of bacterial growths, these effects may be caused by the poisonous proteids or toxins, which are always formed in the beginning of putrefactive processes. Some of the ptomaïns obtained by chemists are not due to putrefactive changes at all, but to the chemical methods employed in separating them.

Toxins or *toxalbumins* may be divided into two groups: (1) *Bacterial proteids* (Buchner), which are poisonous substances of albuminoid nature developed by bacteria, not affected by heat and capable of producing fever and inflammation, and which are obtained by boiling for several hours potato cultures of the organisms and treating with a one-half-per-cent. solution of potassium hydrate. From the clear filtrate thus obtained the proteids are precipitated by dilute acid, and the precipitate washed and dried. The best-known bacterial proteid is Koch's *old tuberculin*; *mallein* is a similar substance. (2) *Toxalbumins* (Brieger and Fraenkel), which are amorphous poisons having an intense and often specific action—that is, an action identical with that produced by infection with the living organism—and obtainable through precipitation from bouillon cultures by agents separating albumin, as alcohol or ammonium sulphate. For this reason these substances were called "toxalbumins," and were regarded as analogous to the toxalbumins of vegetable origin, like ricin from the castor-oil bean and abrin from the jequirity bean. But the majority of investigators consider them to be unstable albuminous substances derived from the bacterial cells; and some have assumed that they were similar to the snake venoms or enzymes, inasmuch as like these latter bodies they are very sensitive to the action of heat, light, and chemical agents. For some time, however, there has been considerable doubt as to whether the so-called toxalbumins were only obtainable by precipitation from albumin, and whether they had anything to do with albumin at all. Recently Brieger and Cohn have succeeded in obtaining what they consider to be an almost pure toxin from the crude poison of the tetanus bacillus, by means of precipitation with lead acetate and ammonia, which does not respond to any of the ordinary tests for albumin and is apparently not an albuminous substance. In the same way the cholera and diphtheria toxins have been obtained and are now recognized as being non-albuminous. It is thus becoming customary to call all proteid bacterial products *toxins*, irrespective of their composition, and to ignore the existence of the above-described crystallizable poisons of simple constitution.

With regard to the other properties of these toxins, taking tetanus toxin as an example, it may be said that in aqueous solution it is not coagulated by heat, but is deprived in time of its poisonous qualities. The addition, and continued passage through it, of CO_2 or H_2S distinctly reduces its toxicity. When exposed to light and air, either in a dry state or in solution, the toxin deteriorates rather rapidly. It withstands a temperature of 70° C. for some time without being wholly destroyed; higher temperatures quickly decompose it. When protected from exposure to light and air it is slowly converted into an inactive substance; it is best preserved under absolute alcohol, pure ether, and the like. The toxicity of the purest tetanus toxin now obtainable is almost incredible and is perhaps the most powerful poison known; 0.00005 mgm. of it kills a mouse of 15 gm. weight; hence a man of 150 pounds weight, if he were equally susceptible, would be killed with 0.23 mgm. In order to appreciate the activity of this toxin, we have only to consider that it requires a dose of from 30 to 100 mgm. of strychnine to kill a man under ordinary circumstances.

Sulphuretted Hydrogen.—This is a very common bacterial product. It may be formed: (1) From albuminous substances; (2) from powdered sulphur; (3) from thiosulphates and sulphites. The presence of sugar in the culture media does not effect the production of H_2S, but saltpetre reduces it, with the formation of nitrites.

Reduction Processes.—All bacteria possess the property of converting sulphur into H_2S in the presence of nascent hydrogen. The following reduction processes brought about by bacteria also depend in part upon the action of nascent hydrogen: The reduction of blue litmus pigments, methylene blue and indigo to colorless substances; the reduction of nitrates to nitrites and ammonia, and even to free nitrogen. The so-called "cholera-red reaction" depends upon the reduction of nitrates to nitrites by the cholera spirillum together with the production of indol. When chemically pure nitric or sulphuric acid is added to nutrient peptone cultures of the cholera spirillum a rose-red or violet color is produced. The mineral acid splits up the nitrites present, setting free nitrous acid which, with the indol, gives the red reaction. Although called "cholera red," this nitroso-indol reaction is

not confined to the cholera spirillum, but may be applied to many other bacteria. Out of sixty species examined by Lehmann, twenty-three gave the indol reaction; but the test is of practical value in differentiating the cholera spirillum from several other similar species for which it may be mistaken.

Denitrification.—This process is brought about by a number of bacteria which separate nitrogen from the nitrates and nitrites. The practical significance of these organisms, the denitrifying bacteria, is that by their action large quantities of nitrates in the soil and in manure, which are necessary for plant food, may thus become lost through conversion into free nitrogen.

Assimilation of Nitrogen.—Although so far as we know none of the higher plants have the power of assimilating nitrogen from the atmosphere, this property is possessed by at least one species of bacteria, the *bacillus radicicola* of Beyerinck. This organism is found in the root nodules of various leguminous plants (peas, clover, lupine, etc.), and can be isolated from these. Different varieties of this bacillus exist in different kinds of legumes, each legume apparently having a special variety adapted to its needs. There are also certain neutral varieties, however, existing free in the soil. By the aid of these root bacteria, leguminous plants are enabled to assimilate nitrogen from the atmosphere, thus enriching sandy soils which are naturally poor in nitrogen, so that they yield good harvests.

Formation of Acids from Carbohydrates.—Many bacteria form free acids in culture media containing carbohydrates (sugar). Acid formation occurs sometimes with and sometimes without the production of gas. Excessive formation of acid may cause the death of the bacteria from the increased acidity of the media in which they are cultivated. All anaërobic and facultative anaërobic species form acids from sugar; the strictly aërobic species do not, or they do it so slowly that the acid is hidden by the almost simultaneous production of alkali (Theobold Smith). If after the sugar is used up not enough acid has been formed to kill the bacteria, the medium becomes again neutralized and finally alkaline. Among the acids produced the most important is lactic acid, also traces of formic, acetic, proprionic, and butyric acids, and not infrequently ethyl alcohol and aldehyde.

Gas Formation.—The only gas produced by bacteria in visible quantity in culture media free from sugar is nitrogen. In the presence of sugar, so long as lactic or acetic acid is produced, there may be no gas production; but frequently gas may be abundantly formed, especially by anaërobic bacteria or in the absence of air. About one-third of the acid-producing species also develop gas, consisting chiefly of carbon dioxide and hydrogen. Bacteria which decompose cellulose also produce marsh gas.

Acid Production from Alcohol.—It has long been known that the conversion of ethyl alcohol into acetic acid is due to the action of bacteria. The conversion of the higher alcohols—glycerin, mannit, etc.—into acids is also caused by bacterial action, as is also the conversion of the fatty acids and their salts into other acids, as for instance the salts of lactic, malic, tartaric, and citric acids into butyric, proprionic, valerianic, acetic acids, etc.

Effects of Outside Influences upon Bacteria.—*Electricity.*—Very little is known about the influence of electricity on bacteria; but the observations heretofore made on this subject would seem to indicate that there is no direct action of the galvanic current on micro-organisms, though the effect of heat and electrolysis may produce changes in the culture which finally sterilize it.

Slight *agitation* of cultures of bacteria seems to act favorably on their development, but protracted and violent shaking destroys the vitality of bacteria by causing a molecular disintegration of their cells.

Pressure exerts comparatively little influence on bacteria. A culture of the bacillus pyocyaneus subjected to a pressure of fifty atmospheres under CO_2 still grew at the end of four hours, but the power of pigment production was lost. After six hours' exposure to this pressure a few colonies still developed, but after twenty-four hours no growth occurred.

Light.—A large number, perhaps the majority, of bacteria are inhibited in growth by the action of diffuse daylight, still more by that of direct sunlight. Dieudonné found that the bacillus prodigiosus exposed to the action of direct sunlight during the months of March, July, and August were killed in an hour and a half; during the month of November, in two and a half hours. Diffuse daylight in March and July inhibited development after three and a half hours' exposure; in November after four and a half hours, and vitality was completely destroyed in from five to six hours. Exposure to the action of the electric arc light inhibited development in five hours and destroyed vitality in eight hours; incandescent light inhibited growth in from seven to eight hours and killed in eleven hours. Similar results have been obtained with other bacteria, as the bacillus coli communis, bacillus typhosus, and bacillus anthracis. The tubercle bacillus was found by Koch to be killed by the action of direct sunlight in from five minutes to several hours, depending upon the thickness of the layer exposed and the season of the year. Diffuse daylight had the same effect in from five to seven days. It has been shown that it is only the ultra violet, violet, and blue rays of the solar spectrum which possess bactericidal action; the green rays very much less, and the red and yellow rays not at all. The action of light is apparently aided in most cases by the admission of air; but anaërobic bacteria, like the tetanus bacillus, and facultative anaërobic species, as the colon bacillus, are able to withstand the action of sunlight quite as well in the absence as in the presence of oxygen. The mechanism of the action of light has been partially explained, at least, by the demonstration of the formation of hydrogen peroxide in cultures exposed to light for a short time.

Influence of One Species of Bacteria upon Another.—If we examine water, milk, or the contents of the intestinal canal of either sick or healthy persons, we invariably find several species of bacteria occurring together. This association may at first seem to be purely accidental; but on further investigation it will be found that there are among bacteria synergists and antagonists, or at least certain species which apparently assist or oppose one another mutually or one-sidedly. This action is sometimes spoken of as *symbiosis* and *enantobiosis* (Nencke). Thus it has been found that many species of bacteria will not grow at all or only scantily in cultures when in close proximity to other species, the action being mutual or one-sided. The practical application of this fact is, in making plates for the isolation of pure cultures or for the counting of colonies, to have the plates as thin as possible. Bacteria may also oppose one another antagonistically in the animal body. Emmerich has shown that animals infected with anthrax may often be cured by a secondary infection with the streptococcus. The symbiotic or co-operative action of bacteria is of still greater importance. Some bacteria thrive better in association with other species than alone. Certain anaërobic species, for instance, as the tetanus bacillus, grow even in the presence of air, if associated with aërobic species. Again, certain chemical effects of bacteria, as denitrification of nitrates, can be produced only when two species are associated together. In like manner it has been observed that some soil bacteria, though non-pathogenic in pure culture, when inoculated into animals in combination with other species may produce disease. Finally, slightly pathogenic species gain in virulence when cultivated with common saprophytic bacteria, as the attenuated tetanus bacillus with the proteus vulgaris.

Lack of Food and Desiccation.—Most bacteria, and especially the pathogenic species, which require much organic nutriment for their development, when placed in distilled water soon die; and even in sterilized water they live from eight to ten days only and rarely multiply. Desiccation affects bacteria in various ways. In dry culture media development soon ceases, although in

media dried gradually at the same temperature bacteria may retain their vitality often for several months and in the absence of spores. Also under natural conditions, when these are favorable, many non-spore-bearing bacteria live a long time when exposed to desiccation. Spore-bearing species, however, are much more resistant to desiccation as also to other injurious outside influences such as heat, light, chemicals, etc.

Behavior toward Oxygen and Other Gases.—As already noted it is customary to divide bacteria into three classes according to their behavior toward oxygen: aërobic, anaërobic, and facultative aërobic and anaërobic species.

Aërobic bacteria grow only in the presence of oxygen; the slightest restriction of air inhibits their development, spore formation especially requiring the free admission of air.

Anaërobic bacteria grow and form spores only in the total exclusion of oxygen. Among this class of organisms are many soil bacteria, such as the bacillus of malignant œdema, the tetanus bacillus, and the bacillus of symptomatic anthrax. Exposed to the action of oxygen, the vegetative forms of these bacteria are readily destroyed; their spores, however, are very resistant. Anaërobic bacteria being deprived of the oxygen of the air, are dependent for their nutriment upon decomposable substances such as glucose. Hence for their cultivation they require, as a rule, media containing from one to two per cent. of glucose or some other equivalent.

Facultative Aërobic and Anaërobic Bacteria.—The greater number of aërobic bacteria, including most of the pathogenic species, are capable of withstanding, without being seriously affected, a considerable restriction of oxygen, and many grow equally well in the partial exclusion of this gas. Life in the animal body, for instance, necessitates an existence with a diminished supply of oxygen. Pigment production usually ceases with the exclusion of oxygen, but toxins are more abundantly formed. The presence of living or dead aërobic species may facilitate the aërobic growth of anaërobic species. Moreover, certain species which in their isolation at first show more or less anaërobic development, have been observed after a time to become aërobes, growing only on the surface of media. The simple fact, therefore, of an organism showing aërobic or anaërobic growth is not sufficient to make of it a distinct species.

Although all facultative as well as obligatory anaërobes grow luxuriantly in nitrogen or hydrogen gas, the same is not true of carbon dioxide gas. Many species do not grow at all but are inhibited or killed by CO_2, while others exhibit only a scanty growth, and very few are not affected. Sulphuretted hydrogen in large quantity is a strong bacterial poison, and in small amount even it destroys some species.

Effect of Temperature.—Every bacterial species makes certain demands on temperature for its growth. Vegetative life is possible within the limits of 0° and 70° C.; but there are some species of bacteria which grow at the lower and others at the upper limits of this range. The maximum and minimum temperatures for each species lie about 30° C. apart. Bacteria have thus been classified, according to the temperature at which they develop, into: (1) *Psychrophilic bacteria.* Minimum growth at 0° C., optimum at 15° to 20° C., maximum at about 30° C. To this class belong the water bacteria having the power of emitting light. (2) *Mesophilic bacteria.* Minimum growth at 10° to 15° C., optimum at 37° C., maximum at about 45° C. These include all the pathogenic species, the conditions for their growth in the animal body requiring acclimatization to the body temperature. (3) *Thermophilic bacteria.* Minimum growth at 40° to 49° C., optimum at 50° to 55° C., maximum at 60° to 70° C. This class includes many soil bacteria and almost exclusively spore-bearing species. They are found widely distributed in fæces.

By carefully elevating or reducing the temperature it is possible to extend the limits within which different species of bacteria will grow. Thus the anthrax bacillus has been made gradually to accommodate itself to a temperature of 42° C., and pigeons, which are comparatively immune to anthrax infection, on account of their high body temperature, when inoculated with this modified organism succumb to the disease. In the same way the anthrax bacillus has been acclimated to a temperature of 12° C., so that it killed frogs kept at this temperature (Dieudonné). A very virulent diphtheria bacillus has been so cultivated that it grew at 43° C. and produced strong toxin (Park).

Bacterial growth, though retarded by temperatures just below the minimum of the species, is not otherwise injured. Cultures of bacteria which readily die (as the streptococcus) are often preserved in laboratories by keeping them in the refrigerator at 4° to 6° C. Temperatures even far below 0° C. are only slowly injurious to bacteria, different species being affected with varying rapidity. Ordinarily, low temperatures, though arresting the growth, do not destroy the vitality of bacteria. Microorganisms have been exposed for hours in a freezing mixture at 18° C. and have been kept in an open tube in liquid air at 175° C. for two hours, and yet have been found to grow when placed again under favorable conditions.

Temperatures from 5° to 10° C. over the optimum, however, affect bacteria injuriously in several ways. The effects produced are the production of varieties of diminished activity of growth, weakening of virulence, and decrease of the property of causing fermentation, and finally gradual loss of power of spore formation. One or other of these effects may predominate under varying conditions.

If the maximum temperature is exceeded the organism soon dies; the thermal death point for psychrophilic species being about 37° C., for mesophilic about 45° to 55° C., and for thermophilic about 75° C. There are no non-spore-bearing bacteria which, when moist, are able to withstand a temperature of 100° C. even for a few minutes. According to Sternberg, ten minutes' exposure to moist heat will kill the cholera spirillum at 52° C., the streptococcus at 54° C., the typhoid bacillus at 56° C., the diphtheria bacillus and gonococcus at 60° C., and the staphylococcus at 62° C., the last mentioned being the most resistant of pathogenic organisms without spores. When bacteria in a desiccated condition are exposed to the action of heated air the temperature required for their destruction is much above that needed when they are moist or exposed to the action of hot water or steam. A large number of bacteria are able to resist dry heat at a temperature of over 100° C. for an hour. A temperature of 120° to 130° C. maintained for an hour and a half is required to destroy all bacteria, in the absence of spores, if hot air is used.

Spores are far more resistant to all injurious influences than vegetative forms, and can withstand also a greater degree of both moist and dry heat. Many spores are able to resist a temperature of 130° C. dry heat, the spores of the anthrax and the hay bacilli requiring, for instance, an exposure of three hours to a temperature of 140° C. to insure their destruction. Moist heat at a temperature of 100° C., either boiling water or streaming steam, destroys the spores of all known pathogenic bacteria within ten minutes; the spores of some non-pathogenic species resist this temperature, however, for hours. While steam under pressure is more effective than streaming steam in practical disinfection,it is scarcely necessary to give it the preference, inasmuch as all known pathogenic bacteria and their spores are quickly destroyed by the temperature of boiling water. "Superheated" steam has about the same germicidal power as hot, dry air at the same temperature, and is less effective, of course, than moist steam.

Tyndalization; Fractional Sterilization.—Certain nutrient media, such as blood serum and the transudates of the body (ascitic and hydrocele fluids, etc.), and some fluid food stuffs, require at times to be sterilized and yet cannot be subjected to temperatures high enough to kill spores without suffering injury. The property of spores, when placed under suitable conditions, to germinate into vegetative forms, is here taken advantage of by heating

the fluids to 55° or 78° C. for one hour on six consecutive days. By this means, upon each exposure, all the bacteria, which have grown in the interval, are killed in the vegetative form. Experience has shown that, with few exceptions, this method of fractional sterilization will completely sterilize all fluids thus treated.

Pasteurization.—It is often undesirable, however, to expose milk and other food stuffs to such a high temperature, because of the deleterious effects produced, and yet a partial sterilization is required. According to the method of Pasteur, however, milk, etc., may be heated for thirty minutes to 70° C., which will kill all vegetative bacteria present, allowing only the spores to remain alive. But even this partial sterilization greatly retards the process of fermentation or putrefaction.

Effect of Chemical Agents.—Many chemical substances when brought in contact with bacteria unite with their cell substance, forming new compounds and usually destroying the life of the organisms. Bacteria are much more easily killed by chemicals when in the vegetative than in the spore stage, and their life functions are inhibited by substances less injurious than those required to destroy their vitality. But both in the vegetative and spore forms they differ considerably in their resistance to chemical agents. The reason for this is but imperfectly understood, but it probably depends upon the composition of their cell substance, and is due to a true chemical combination taking place. Chemicals are more destructive to bacteria at a high than at a low temperature, and they act more quickly when the bacteria are suspended loosely in fluids than when in masses. In estimating the extent of the action of chemical agents upon bacteria we usually distinguish the following degrees:

1. *Attenuation.*—The growth is not permanently interfered with, but the pathogenic and zymogenic functions of the organism are diminished.
2. *Asepsis or Inhibition.*—The organisms are not able to multiply, but they are not destroyed.
3. *Antisepsis, or Incomplete Sterilization.*—The vegetative development of the organism is destroyed, but not the spores.
4. *Disinfection, or Complete Sterilization.*—Vegetative forms and spores are destroyed.

Many substances which are strong disinfectants become altered under the conditions in which they are used, so that they lose a part, if not all, of their germicidal properties. Thus quicklime and milk of lime are disinfecting agents only so long as sufficient calcium hydroxide is present. If this is changed by the carbon dioxide of the air into carbonate of lime it becomes inert. Bichloride of mercury and other chemicals form compounds with many organic and inorganic substances, which, though still germicidal, are much less so than the original substances.

DISINFECTANTS.—Among the more commonly used disinfectants may be mentioned:

I. *Mineral Disinfectants.*—*Bichloride of mercury.* This substance in the proportion of 1 to 1,000,000 in nutrient gelatin or bouillon, prevents the development of parasitic bacteria. In the proportion of 1 to 500,000 in water it will kill many species in a few minutes, but in bouillon twenty-four hours may be needed. With organic substances its power is lessened, so that 1 part in 1,000 may be required. Spores are killed in 1 to 1,000 watery solution within one hour. Corrosive sublimate is therefore less effective as a germicide in alkaline solutions containing much albumin than in aqueous solutions. In such fluids, besides loss in other ways, albuminate of mercury is formed, which is at first insoluble, so that a part of the mercuric salt is really inert. In alkaline solutions, such as blood, blood serum, pus, tissue fluids, etc., the soluble compounds of mercury are converted into oxides or hydroxides. The soluble compounds can therefore remain in solution only when there are present sufficient quantities of certain bodies (the alkaline chlorides and iodides, sodium and ammonium chlorides) which render solutions possible. The addition of a suitable quantity of common salt to the corrosive sublimate thus prevents the precipitation of the mercury. Compounds of mercury which, like the cyanides, are not precipitated with alkalies, because they form double salts, require no addition of salt. For ordinary use, solutions of 1 to 500 and 1 to 1,000 of bichloride of mercury will suffice to kill the vegetative forms of bacteria within fifteen minutes; when much organic matter is present the stronger solution should be used.

Biniodide of mercury is very similar in its effects to the bichloride, and is even more powerful.

Nitrate of silver in solution has about one-fourth the germicidal value of bichloride of mercury, but nearly the same antiseptic value.

Sulphate of copper has about five per cent. the value of mercuric chloride.

Sulphate of iron is a very feeble disinfectant.

Caustic soda in a thirty-per-cent. solution kills anthrax spores in about ten minutes; in four-per-cent. solution in about forty-five minutes.

Sodium carbonate even in concentrated solution kills spores with difficulty, but at 85° C. it kills spores in from eight to ten minutes; a five-per-cent. solution kills the vegetative forms of bacteria in a short time Ordinary soap suds have a slight bactericidal as well as marked cleansing effect. The bicarbonate of soda has almost no destructive action on bacteria.

Calcium hydroxide is a powerful disinfectant; the carbonate has little or no germicidal action. A one-per-cent. solution of calcium hydroxide in water kills bacteria in vegetative form within a few hours; a three-per-cent. solution kills typhoid bacilli in one hour; a twenty-per-cent. solution added to equal parts of fæces and thoroughly mixed completely sterilizes them in one hour.

Mineral acids, bulk for bulk, are more germicidal than vegetable acids. But any acid which equals 40 c.c. of normal hydrochloric acid will prevent the growth of all species of bacteria and will kill many. Twice this amount destroys most bacteria in a short time. A 1 to 500 solution of sulphuric acid kills typhoid bacilli within an hour. Hydrochloric, citric, tartaric, malic, formic, and salicylic acids are similar to acetic acid in germicidal properties. Boric acid destroys the less resistant bacteria in two-per-cent. solution and inhibits the growth of others.

II. *Organic Disinfectants.* — *Alcohol* in ten-per-cent. solution inhibits the growth of bacteria; absolute alcohol kills bacteria in the vegetative form in from several to twenty-four hours.

Chloroform, even when chemically pure, does not destroy spores, but a one-per-cent. solution will kill bacteria in vegetative form.

Iodoform has but little destructive action on bacteria, and upon most species has no appreciable effect at all. When mixed with pus from wounds, etc., iodoform is reduced to soluble iodine compounds, which partly act destructively upon the bacteria and partly unite with the poisons produced by them.

Carbolic acid in aqueous solutions 1 to 1,000 inhibits the growth of bacteria; in the proportion of 1 to 400 it kills the less resistant organisms, and in 1 to 100 solution destroys all vegetative forms. A five-per-cent. solution kills the less resistant spores in a few hours and the more resistant in from one day to four weeks; a slight increase of temperature aids the destructive action. A three-per-cent. solution kills streptococci, staphylococci, anthrax bacilli, etc., within one minute. Carbolic acid loses much of its value when in solution with alcohol or ether, but the addition of 0.5-per-cent. hydrochloric acid aids its activity. Carbolic acid is so permanent and comparatively so little influenced by the presence of albumin, that it is one of the best agents for general use in practical disinfection.

Cresol is the chief ingredient of so-called "crude carbolic acid." It is almost insoluble in water and has therefore little germicidal value. Mixed with equal parts of sulphuric acid to render it soluble it is a powerful disinfectant, but it is then strongly corrosive.

Creolin is an alkaline emulsion of the cresols and other products contained in crude carbolic acid with soap, and is as powerfully disinfectant as pure carbolic acid; it is used in five-per-cent. emulsions.

Lysol is similar to creolin and has about the same germicidal value.

Tricresol is a refined mixture of the three cresols (meta-, para-, and orthocresol); it is soluble in water to the extent of 2.5 per cent., and is about three times as strong as carbolic acid.

The *aniline dyes*, many of them, possess marked germicidal properties. Methyl violet and malachite green destroy the typhoid bacillus in bouillon cultures in 1 to 200 solution in two hours, and the pyogenic cocci in less time. Even in 1 to 100,000 solution they are said to inhibit bacterial growth.

The *essential oils* are also strongly disinfectant. Oil of cinnamon, cloves, thyme, sandalwood, etc., destroy most bacteria in from one to twelve hours. Thymol and eucalyptol have about one-fourth the strength of carbolic acid. Oil of peppermint in 1 to 100 solution inhibits bacterial growth. Oil of turpentine in 1 to 200 solution does the same. Camphor has very little antiseptic action. (See also article on *Disinfectants*.)

III. *Gaseous Disinfectants.—Formaldehyde* is a gaseous compound of strongly disinfectant properties and possessed of an extremely irritating odor. At a temperature of 68° F. the gas is polymerized, that is to say, a second body is formed composed of a union of two molecules of CH_2O. This is known as "paraformaldehyde," and is a white soapy substance, soluble in boiling water and alcohol; it exists in the solution of commerce ordinarily called "formalin," which is a clear watery liquid containing from 33 to 40 per cent. of the gas and 10 to 20 per cent. of methyl alcohol, its chief impurity. When this is concentrated, about 40 per cent. paraformaldehyde results. Dried over sulphuric acid a third body—"trioxymethylene"—is produced, consisting of three molecules of CH_2O, and is a white substance almost insoluble in water or alcohol, and giving off a strong odor of formaldehyde. The solid polymers of formaldehyde when heated are again reduced to the gaseous condition; ignited they finally take fire and burn with a blue flame, leaving but little ash.

Formaldehyde has an active affinity for many organic substances and forms with some of them definite chemical combinations. It combines readily with ammonia to produce a compound called ammoniacal aldehyde which possesses neither odor nor the antiseptic properties of formaldehyde. This action has been made use of in neutralizing the odor of formaldehyde when it is desired to dispel it rapidly after disinfection of habitations. Formaldehyde also forms combinations with certain aniline colors, viz., fuchsin and safronin, modifying their shades. The most delicate fabrics of silk, wool, cotton, fur, leather, etc., however, are unaffected in texture or color by formaldehyde. Iron and steel are attacked after long exposure to the gas or its solution; but copper, brass, nickel, zinc, silver, and gold work are not at all acted upon. Formaldehyde unites with nitrogenous products of decay, fermentation, and putrefaction, forming true chemical compounds, which are odorless and sterile. It is thus a complete deodorizer. Formaldehyde has a peculiar action upon albumin, which it transforms into an insoluble and indecomposable substance. It is to this property of combining chemically with albuminous substances forming the protoplasm of bacteria that formaldehyde owes its germicidal powers. It is also an excellent preservative of organic products for the same reason; and use has been made of it to preserve meat, milk, and other food products. But according to Trillat and others it renders these substances indigestible and unfit for food. It has been successfully employed, however, as a preservative of botanical, pathological, and histological specimens.

The vapors of formaldehyde are extremely irritating to the mucous membrane of the eyes, nose, and mouth, causing profuse lachrymation, coryza, and secretion of saliva. Aronson has stated that rabbits and guinea-pigs, allowed to remain for twelve to twenty-four hours in rooms which were being disinfected with formaldehyde gas, were unaffected by the fumes. But other experimenters have found that animals, such as dogs, cats, etc., accidentally exposed for some time to the action of the gas, suffered severely, and some have died from its effects. It would seem, therefore, that although formaldehyde is comparatively non-toxic to the higher forms of animal life, nevertheless a certain degree of caution should be observed in its use. Roaches, flies, bedbugs, and other insects are, as a rule, not killed by formaldehyde gas in the process of disinfecting a room.

The results of numerous experiments in practical disinfection with this agent have shown that two and one-half per cent. by volume of the aqueous solution of formaldehyde, or one per cent. by volume of the gas, are sufficient to destroy the vegetative forms of pathogenic bacteria in a few minutes, when freely exposed to its influence and in a moist condition. The germicidal power of the gas depends not only upon its concentration, but also upon the temperature and the condition of the object to be sterilized. As with other gases, it has been found that the action is much more rapid and complete at higher temperatures (35° to 45° C.), and when the test objects are moist and freely exposed, than at lower temperatures and when the objects are dry and in mass; the gas possesses when dry little or no penetrative power. Still it has been repeatedly demonstrated that it is possible to disinfect the surface of rooms, and articles contained in them, under the conditions of temperature and moisture ordinarily found, by an exposure of a few hours to a saturated atmosphere of the gas.

Sulphur dioxide gas has been extensively used for the disinfection of hospitals, ships, apartments, etc. Its action depends upon the formation of sulphurous acid in the presence of moisture. In its pure state SO_2 does not destroy spores, and even on vegetative forms its germicidal effect is uncertain. An exposure, however, for eight hours to an atmosphere containing at least four volumes per cent. of this gas in the presence of moisture will destroy most, if not all, the common non-spore-bearing pathogenic bacteria. It is not so prompt or powerful in its action as formaldehyde gas, which in many respects is a preferable disinfectant, especially in cases where the sulphurous acid formed from the sulphur dioxide may have an injurious effect upon the articles to be disinfected.

Peroxide of hydrogen is an energetic disinfectant, and in two-per-cent. solution (about forty per cent. of the ordinary commercial article) will kill the spores of anthrax in from two to three hours. A twenty-per-cent. solution of good commercial peroxide of hydrogen will quickly destroy the pyogenic cocci and other non-spore-bearing bacteria. On account of its rapidity of action and non-poisonous character it is a useful and safe disinfectant, but it combines with organic matter and becomes inert, being apt to deteriorate if not properly kept.

Chlorine is a powerful gaseous germicide, owing its activity to its affinity for hydrogen and consequent release of nascent oxygen, when it comes in contact with micro-organisms in a moist condition. Like formaldehyde gas and sulphur dioxide it is much more active in presence of moisture than in a dry condition. Dried anthrax spores exposed for an hour in an atmosphere containing 44.7 per cent. of dry chlorine were not destroyed; whereas when the spores were previously moistened and exposed in a moist atmosphere for the same time, four per cent. was effective, and when the time was extended to three hours, one per cent. destroyed their vitality. The anthrax bacillus, in the absence of spores, was killed by an exposure in a moist atmosphere containing 1 part to 2,500 for twenty-four hours. In watery solution 0.2 per cent. kills spores within five minutes and the vegetative forms almost immediately.

Chloride of lime owes its efficacy to the chlorine it contains in the form of hypochlorites. A solution of one-half to one per cent. of fresh chloride of lime in water will

kill most bacteria in from one to five minutes; a five-per-cent. solution usually destroys spores in an hour.

Bromine and *iodine* are of about the same germicidal value as chlorine, in the moist condition; but, like chlorine, they are not applicable for general use in house disinfection on account of their poisonous and destructive properties. They are useful for the disinfection of sewers, and other similar places. Trichloride of iodine in 0.5-per-cent. solution destroys the vegetative forms of bacteria in about five minutes.

(*The relation of bacteria to disease*—infection, susceptibility, resistance, immunity, recovery, etc.—will be considered elsewhere; as will also the subject of *bacteriological technique.*)

Special Bacteria.

Under this heading will be described the chief characteristics of the more important bacterial species pathogenic for man and other animals. There are many bacteria which have been found in certain diseases, but their causal relation to the disease has not yet been proven, and they have also been found in other affections. These we cannot treat of here. Nor will space allow us to consider the non-pathogenic species, or those which do not affect man, but are pathogenic for the lower animals only.

The Tubercle Bacillus (*Koch's Bacillus Tuberculosis*).—The infectious nature of tuberculosis was first demonstrated by Villemin in 1865, when by inoculation with tuberculous material he communicated the disease to healthy susceptible animals. In 1882 Koch discovered the bacillus tuberculosis, which is now known to be the specific cause of the disease.

Microscopical Appearances.—The tubercle bacillus occurs in sputum and in cultures as slender rods from 1.5 to 4 μ long and about 0.4 μ broad, often slightly curved. The bacilli usually occur singly, but in cultures sometimes form chains of four to six elements; occasionally peculiar, club-like forms and branches have been met with, from which they have been supposed to be allied to the actinomyces group of fungi or streptothrices (see Plate X., Fig. 1).

Motility.—Non-motile.

Spore Formation.—The clear spaces or vacuoles which are present in stained preparations, and which have been described by some authorities as spores, are probably due to degenerative processes, as they do not show the form of spores nor is anything known as to their power of resistance or germination.

Staining Reaction.—The tubercle bacilli stain with difficulty, but once stained they retain the dye with great tenacity. At present the methods most commonly employed for staining tubercle bacilli, though there are many modifications of these, are the Ziehl-Neelsen with carbol fuchsin, and the Koch-Ehrlich with aniline water and gentian violet. For special methods of preparing and staining cover-glass specimens and sections, see *Micro-Organisms: Technology.*

The peculiar staining reaction found in the case of the bacillus tuberculosis is not confined to that organism alone, as other similar organisms, when treated in like manner, react in the same way. Thus it has to be differentiated from the *smegma bacillus*, located in the smegma, often seen beneath the prepuce and upon the vulva, both normally and in disease; *Lustgarten's bacillus of syphilis*, found principally in the primary lesions associated with that disease; the *bacillus of leprosy;* and *acid-resisting* or *grass bacteria* found in butter. Hueppe differentiates the first three organisms and the tubercle bacillus as follows:

1. Treat the preparation, stained with carbol fuchsin, with sulphuric acid, and the syphilis bacillus, if present, is at once decolorized.

2. If not immediately decolorized, treat with alcohol, and if it is the smegma bacillus it will lose color.

3. If it is still not decolorized, it is either the leprosy or the tubercle bacillus. According to Baumgarten, the leprosy bacillus is stained by an exposure of six or seven minutes to a cold saturated, watery solution of fuchsin, and retains the stain when subsequently treated with acid alcohol (nitric acid 1 part to alcohol 10 parts). When treated for the same length of time, the bacillus tuberculosis does not ordinarily become stained.

Biological Characters.—Aërobic; does not grow in the absence of oxygen. Growth takes place between 29° and 42° C.; optimum temperature at 37° C. Under all circumstances the growth is slow. On the ordinary agar and gelatin culture media development is very scanty; for the cultivation of tubercle bacilli practically the only media employed are coagulated blood serum and four to six per cent. glycerin agar and glycerin bouillon.

It is very difficult to obtain a *pure culture* of tubercle bacilli, because they grow so slowly and require for their development an incubator temperature, and because owing to the slow growth, the other bacteria present in tuberculous material, as sputum, grow more rapidly and take possession of the culture medium before the tubercle bacillus has had time to form colonies. It is therefore best, unless human tissues can be obtained free from other infection, first to inoculate some guinea-pigs (which are very susceptible) both subcutaneously and intraperitoneally, with the sputum, and then to obtain cultures from the animal as soon as the tuberculous infection has fully developed. The animals thus inoculated usually die at the end of three to four weeks or more. It is better, however, to kill a guinea-pig which by its enlarged glands shows evidence of tuberculosis, and to remove, with the greatest antiseptic precautions, one or more nodules from the lungs, spleen, or lymphatic glands, and inoculate with this the solid culture medium (blood serum) by rubbing it directly over the surface; or a part of it may first be crushed between two sterilized glass slides and then transferred to the serum and gently rubbed over its surface.

Growth on Coagulated Blood Serum.—On this medium, which is generally employed to obtain the first culture, the growth becomes visible after ten to fourteen days at 37° C., and at the end of three to four weeks a distinct, characteristic development has occurred. Small, grayish-white, dry, crumbly scales first appear on the surface; then as development progresses there is formed an irregular, membranous-looking layer. On removing a small portion of this and placing it on a cover glass without rubbing, staining, and examining under the microscope, the bacilli will be seen to present a characteristic appearance and to be arranged in parallel rows of variously curved figures.

Growth on Glycerin Agar.—Owing to the greater facility of preparing and sterilizing glycerin agar, and the more rapid and abundant development of the bacilli, which have become accustomed to growth outside the body, this medium is now usually employed in preference to blood serum for preserving cultures. At the end of fourteen to twenty-one days the development is more luxuriant than upon blood serum after several weeks. When numerous bacilli have been distributed over the surface of the medium, a rather uniform, thick, white layer, which later becomes yellowish in color, is developed; when the bacilli are few in number, separate colonies are developed with more or less irregular outlines.

Growth on Glycerin Bouillon.—On bouillon containing about five per cent. of glycerin the tubercle bacillus also grows readily if a fresh thin film of growth from the glycerin agar is floated on the surface. This medium is used for the production of "tuberculin." The small piece of pellicle removed from the previous culture continues to enlarge while it floats on the surface of the liquid, and in the course of from three to six weeks covers it completely as a single film, which on agitation breaks up and settles to the bottom of the flask, where it ceases to develop further. The liquid remains clear, containing in solution the products formed by the growth of the bacillus.

Vitality.—Tubercle bacilli in pure cultures are very susceptible to the action of direct sunlight, being destroyed in from a few minutes to some hours, according to the thickness of the growth. Exposed to diffuse day-

light they are killed in a week. Though they do not form spores, as far as known, the bacilli have a somewhat greater resisting power to heat and desiccation than many other pathogenic bacteria, frequently retaining their virulence in a dried condition at the ordinary temperatures for months. Portions of the lung from a tuberculous cow, dried and pulverized, produced tuberculosis in guinea-pigs at the end of one hundred and two days. Dried tuberculous sputum may retain its virulence for two or three months or more. An instance is reported by Ducor of a healthy family having become infected with tuberculosis from living in a room which had been occupied by a consumptive patient two years before, and on examining the sputum-stained wallpaper not only were tubercle bacilli found in it, but when inoculated into guinea-pigs they died of the disease. Exposure to 100° C. dry heat does not kill the bacilli in twelve hours; but moist heat at 60° C. destroys them in fifteen minutes. Cold has little or no effect upon them. The resisting power of this bacillus against chemical disinfectants is considerable, especially in sputum, where the organisms are protected by mucus from penetration by the germicidal agent. They are not always destroyed by the gastric juice in the stomach, as has been shown by successful experiments in feeding to susceptible animals. They are killed in sputum in about six hours by an equal amount of a three-per-cent. solution of carbolic acid, and in about one hour by a five-per-cent. solution. Bichloride of mercury is unsuitable for the disinfection of sputum unless used in very strong solution (1 to 500). Pickling and smoking are said not to destroy the virulence of tuberculous meat.

Occurrence.—The tubercle bacillus is a strict parasite, —that is to say, it does not grow under natural conditions outside of the bodies of man and animals. It has frequently been found, however, in the dust of hospitals, dwellings, railways, street cars, etc., in places where consumptives have expectorated. Very rarely has it been found in the air. The milk of tuberculous cows, even when the udder is not affected, very often contains tubercle bacilli; they are also found in butter.

Post-mortem examinations of many individuals who have died from some other cause than tuberculosis have revealed the presence of healed tuberculous foci. It has been estimated that sixty-six per cent. of all mankind have some evidence of tuberculosis, old tuberculous lesions, of primary or secondary origin. Tubercle bacilli are said to have been found also in the secretions of the nose and throat of healthy persons, nurses and doctors, who have been in constant association with tuberculous patients.

The tubercle bacillus is the essential cause of all forms of tuberculosis: the various affections of the lungs and other organs, lupus, scrofula, and inflammation of the bones and joints. The following diseases have also been traced to tuberculous infection: so-called "inoculation lupus," tuberculosis verrucosa cutis, and scrofuloderma; choroidal tuberculosis, idiopathic pleurisy, etc. Indeed, all organs and portions of the body may become affected with this disease.

Many cases of tuberculosis are produced by the tubercle bacillus alone, but very frequently streptococci and other pyogenic cocci play an important part in the production of fever and the destruction of tissue, as in phthisis, by suppurative processes.

Tuberculosis is very common among cattle, chiefly in cows and rarely in calves. According to Klepp, from abattoir inspections in Germany, up to thirty-five per cent. of cattle, eighty per cent. of cows, and three per cent. of calves, are commonly found tuberculous. The disease is also quite frequent in young pigs; less so in sheep, goats, horses, dogs, and cats. Rabbits and guinea-pigs are also not uncommonly spontaneously affected with tuberculosis, when kept in cages together with infected animals. Monkeys in confinement almost invariably die from tuberculosis. Wild animals are comparatively free from the disease; and so are birds, except canaries and parrots.

Pathogenesis.—As seen from the above many animals besides man are naturally susceptible to tuberculosis. Among test animals guinea-pigs are the most susceptible, and on this account they are commonly used for the detection of tubercle bacilli in suspected material by inoculation. When inoculated with the minutest quantity of living tubercle bacilli they usually succumb to the disease. Infection is most rapidly produced by intraperitoneal injection, death following a large dose in from ten to twenty days. On autopsy the omentum is found to be constricted in sausage-like masses and converted into hard knots containing many bacilli. There is often no fluid in the peritoneal cavity, but generally in both pleural sacs. The spleen is enlarged, and the various organs contain tubercle bacilli. After smaller doses death may be prolonged from four to eight weeks, when the peritoneum and interior organs are found to be filled with tubercles. On subcutaneous injection into the abdominal wall there is thickening of the tissues about the point of inoculation, which breaking down in a week leave a sluggish ulcer covered with cheesy matter. The neighboring lymph glands are swollen, and after two or three weeks they may attain the size of hazelnuts. Soon an irregular fever is set up, and the animal becomes emaciated, usually dying within four to eight weeks. If the injected material contain only a few bacilli, the wound at the point of inoculation may heal and death be postponed for a long time. The lymphatics undergo cheesy degeneration, the spleen is much enlarged, and throughout its substance, which is dark red in color, are masses of nodules. The liver is also enormously swollen, streaked brown and yellow, and the lungs are filled with grayish tubercles; but the kidneys, as a rule, contain no tubercles. Tubercle bacilli are always found in the diseased tissues, but the more chronic the process the fewer are the bacilli present.

Rabbits are also quite susceptible to tuberculosis by inoculation, but much less so than guinea-pigs. In these animals death almost always follows injection of tuberculous material into the anterior chamber of the eye; producing local lesions, softening of the neighboring lymph glands, lesions of the lungs, general miliary tuberculosis, and death in several weeks or months. Subcutaneous inoculations are very much less effective; but intravenous and intraperitoneal inoculations usually cause general tuberculosis and death in a few weeks. Field mice and cats are also readily infected by artificial inoculation; rats, white mice, and dogs only when very large doses are given. Canaries and parrots are susceptible; fowls and pigeons only slightly so; and other birds and cold-blooded animals are apparently immune.

Besides the artificial modes of infection already alluded to, tuberculosis may be produced in animals susceptible to the disease by *feeding* them with tuberculous material. This has been repeatedly done with milk, sputum, etc., containing tubercle bacilli. Here evidence of infection is usually shown in the mesenteric glands before the intestinal walls are affected; indeed, there may be no local lesions in the intestines at all. Under such conditions, infection is probably caused by absorption of the poisons through serous or mucous membranes.

The experimental production of tuberculosis by *inhalation* of bacilli has been demonstrated by Koch in guinea-pigs, rabbits, mice, etc. In these cases the bacilli were usually administered in the form of fine spray; the inhalation of dry tuberculous dust has seldom proved experimentally successful.

The tubercle bacillus acts upon the tissues by means of the poisons which it produces as the result of its growth. Soon after entrance into the tissues of either living or dead bacilli, the cells surrounding them begin to show signs of irritation. The connective-tissue cells become swollen and undergo mitotic division, the resultant cells being distinguished by their large size and pale nuclei. A small focus of proliferated epithelioid cells is thus formed about the bacilli, and according to the intensity of the inflammation these cells are surrounded by a larger or smaller number of the lymphoid cells. When living bacilli are present and multiply, the lesions

progress, the central cells degenerate and die, and a cheesy mass results, which later may lead to the formation of cavities. Dead bacilli, on the other hand, give off sufficient poison to cause less marked changes only, and never produce cavities. Of the gross pathological lesions produced in man by the tubercle bacilli the most characteristic are small nodules, the so-called miliary tubercles. These when young, and before they have undergone degeneration, are gray and translucent in color, somewhat smaller than a millet seed in size, and hard in consistence. But miliary tubercles are not the sole tuberculous products. The tubercle bacilli may cause the diffuse growth of tissue identical in structure with that of miliary tubercles—that is, composed of a basement substance containing epithelioid, giant, and lymphoid cells. This diffuse tubercle tissue also undergoes cheesy degeneration.

When caseation is rapidly spreading, as in acute tuberculosis, the bacilli are usually abundant, being scattered in irregular groups through the tissues. Occasionally they are found in the leucocytes, and in the giant and epithelioid cells. The more chronic the lesions the fewer they are in number.

Modes of Infection.—The chief modes of infection by the tubercle bacillus are through the respiratory tract or the intestines, more rarely through wounds of the skin, and still more rarely through the sexual organs. Pulmonary tuberculosis, as a primary infection, and not occurring in young children, may be considered to be caused chiefly by the direct transmission of tubercle bacilli through kissing, soiled hands, handkerchiefs, etc., or by the inhalation of tuberculous dust. Intestinal and mesenteric tuberculosis, which is rare among adults and common with children, is probably due not only to swallowing the bacilli received in the above-mentioned ways, but also to the ingestion of tuberculous milk. Lupus is probably always produced by the inoculation of tubercle bacilli on the skin or mucous membranes, the original seat of the disease being often on a wounded surface. Localized skin tuberculosis is sometimes produced by accidental inoculation at autopsies. The transmission of infection through the sexual organs of the male or female, though possible, is extremely rare. There seems to be some evidence of the communication of tuberculous infection from the mother to the fœtus in animals; and two cases are recorded of probable placental tuberculosis in the human fœtus. But we have no reason to suppose that infection of the ovum of healthy mothers from the paternal side ever does occur, even when the father has tuberculosis of the scrotum or seminal vesicles. The mere fact that statistics show a greater frequency of tuberculous diseases in children during the first than in the following years of life does not strengthen the hypothesis of infection *in utero*; for nursing babies would naturally be more exposed to infection through the mother's milk and through personal contact than others; and, besides, the more tender the life of the infant the more susceptible it would be ordinarily to indirect infection from a tuberculous mother.

By far the commonest mode of infection, therefore, is undoubtedly by means of tuberculous sputum, which, being coughed up by consumptives and carelessly expectorated, dries and distributes numerous virulent bacilli in the dust. As long as the sputum remains moist there is no danger of dust infection, but only of direct contact. A great number of the expectorated and dried bacilli very probably die, especially when exposed to the action of direct sunlight; but when we consider the enormous masses which are expectorated,* it is evident that a sufficient quantity remains alive to produce infection in the immediate vicinity of consumptives unless precautions are taken to prevent it. There is comparatively little danger of infection in the streets or at a distance from consumptive patients, because even if present in the dust, the tubercle bacilli have become so diluted that they are not much to be feared. It may, therefore, be said that the probability of infection from tuberculosis in general is not so great after all, but at the same time it is all the more to be dreaded and guarded against in the immediate neighborhood of consumptives. Those who are most liable to infection from this source are the families, nurses, fellow-workmen, fellow-prisoners, etc., of persons suffering from the disease. In this connection, also, attention may be drawn to the fact that rooms which have been recently occupied by consumptives are not infrequently the means of producing infection (as has been clinically and experimentally proved) from the deposition of tuberculous dust on furniture, walls, floors, etc. Flügge has lately pointed out that in coughing, sneezing, and even in speaking, very fine particles of secretion, containing tubercle bacilli, may be thrown out and carried by air currents many feet from the patient and remain suspended in the air for a considerable time. For this reason consumptives should be careful to hold their hands or a handkerchief before their mouths, or at least avoid as much as possible contaminating other persons with whom they come in contact.

Phthisical sputum, however, cannot be held responsible for the occurrence of all human tuberculosis. Milk also serves as a frequent conveyer of infection, whether it be the milk of nursing mothers suffering from consumption or the milk of tuberculous cows. The transmission of tubercle bacilli in the milk of tuberculous cows has been abundantly proved by feeding and inoculation experiments on animals. Formerly it was thought that in order to produce infection by milk there must be local tuberculous infection of the udder; but it is now known that tubercle bacilli may be found in milk when an internal organ is infected, and when no disease of the udder, so far as careful inspection goes, seems to exist. The milk of all cows, therefore, which have any tuberculous infection whatever, must be considered as possibly containing tubercle bacilli. With regard to the flesh of tuberculous cattle, the same conditions hold good as in the infection by milk, only the danger is considerably less from the fact that meat is usually cooked, and also because the muscular tissues are seldom attacked. In view of the great mortality from tuberculous diseases among mankind, the legislative control and inspection of cattle and milk would seem to be an absolute necessity. As a practical and simple method of preventing infection, especially among children, the sterilization (by heat) of the milk used as food must commend itself to all. At the same time, it should be stated, however, that there is very little actual proof that human tuberculosis has come from milk or food infected with bovine tuberculosis, nor do we know positively whether the bacilli of bovine tuberculosis are equally as virulent for man as for animals. But from the fact that human tuberculosis produces bovine tuberculosis, there is strong presumptive evidence of the reverse also being true.

Individual Susceptibility.—Another most important factor in the production of tuberculosis, as of all infectious diseases, is individual susceptibility. That this susceptibility or "predisposition," improperly so called, may be either inherited or acquired is now an accepted fact in medicine. There is no doubt that great differences exist in different persons in their susceptibility to tuberculosis, as there are also differences in the intensity of the tuberculous process in the lung. The fact that individuals contracting tuberculosis from the same source are attacked with different severity, and that there is, as a rule, no great variation in degrees of virulence in the tubercle bacilli of different origin, shows that this depends upon something else than a variation in virulence of the infection. The results of post-mortem examinations also demonstrate that many cases of pulmonary tuberculosis evidently occur without showing any visible signs of disease, and heal spontaneously. The possibility of favorably influencing, in an existing tuberculosis, the course of the disease by treatment proves, too, that under natural conditions there is a varying susceptibility. Clinical experience teaches likewise, that the children

* Nutall has estimated that from one and one-half to three billion virulent tubercle bacilli may be expectorated by a single tuberculous individual in twenty-four hours.

born of tuberculous parents, and persons living in poor hygienic conditions and depressing surroundings, as in prisons, asylums, and convents, and those suffering from exhausting diseases, more especially bronchial affections, diabetes, typhoid fever, etc., are more susceptible to tuberculosis than others not so situated or affected. Animal experiments, moreover, have shown that not only are there differences of susceptibility in various species, but also an individual susceptibility in the same species. The doctrine of individual susceptibility, therefore, is apparently founded on fact, although the reasons for it are only partially understood.

Immunization; Koch's Tuberculin.—As in other infectious diseases, many attempts have been made to produce an artificial immunity against tuberculosis, but so far the results have been unsatisfactory. Among the numerous agents that have been tried to protect animals against the action of the tubercle bacillus, the most important is Koch's tuberculin. Tuberculin contains all the products of the growth of the tubercle bacillus in nutrient bouillon and certain substances extracted from the bodies of the bacilli themselves; also the albuminoid and other materials originally contained in the bouillon which are unaffected by the growth of the bacilli. There are two preparations known respectively as the "old" and the "new" tuberculin or "tuberculin T. R."

Old tuberculin is prepared as follows: The tubercle bacillus is cultivated in peptone-glycerin-bouillon. At the end of from three to six weeks, according to the rapidity with which the culture grows, an abundant development takes place with the formation of a thick, dry, white crumpled layer, which finally covers the entire surface of the bouillon. (It was originally inoculated on the surface.) After development ceases, this layer breaks up and sinks to the bottom of the flask. Fully developed cultures, having been tested for purity by microscopical examination, are evaporated by boiling to one-tenth of their original bulk. The liquid is then filtered, and the crude tuberculin thus obtained contains forty to fifty per cent. of glycerin (the broth medium contained four to five per cent.), and keeps well, retaining its activity indefinitely. This substance when injected into tuberculous individuals affects the tuberculous process in a peculiar way. Very small doses produce a moderate increase of inflammation with slight elevation of temperature in tuberculous persons, while healthy individuals have neither fever nor marked local symptoms. The following is the method of treatment employed. After each injection, which should be large enough to cause a slight but not a great rise of temperature, a noticeable change in the tuberculous process results. The amount of tuberculin injection is constantly increased, so as to continue the moderate reactions. After several months all reactions cease, the patients having become temporarily immune to the toxin, but not to the growth of the bacillus. Further injections are now useless, until this immunity has passed. Inasmuch as the bacilli themselves have not been directly affected by the treatment, when this is interrupted the tuberculous process is apt to progress (Koch).

Although Koch and some of his followers have apparently, from their reports, obtained satisfactory results in the treatment and immunization of man and animals with old tuberculin, the majority of investigators, after a short period of enthusiasm, have abandoned its use as very rarely beneficial, if not often injurious. Koch has, therefore, attempted to improve his method and has recommended a new preparation under the name of "*Tuberculin T R.*," or *new tuberculin*. The substances produced in the body by the old tuberculin neutralized the tuberculous toxins, according to Koch, but were not bactericidal. This he considered due to the nature of the envelope of the tubercle bacillus, which rendered it difficult to obtain the substance of the bacilli in soluble form without so altering it by heat or chemicals that it was useless for immunizing purposes. Immunity, he thought, was not produced in man for similar reasons, the bacilli never giving out sufficient toxin, perhaps, to bring about the production of curative substances. He therefore decided to grind up the dried bacilli and soak them in water, and thus obtain, if possible, without the aid of heat, a soluble extract of the cell substance of the bacilli, which he hoped would be immunizing. Buchner, by crushing under a great pressure tubercle bacilli mixed with sand and thus squeezing out their protoplasm, has obtained a similar substance, which he calls "tuberculoplasmin." The new tuberculin is thus a watery extract of the soluble portions of the unaltered tubercle bacilli. Owing to the method of preparation, it is evident that contamination is difficult to avoid, freedom from intact bacilli is uncertain, and the strength of the solution is variable. Twenty per cent. of glycerin is added to preserve the preparation. After three years' trial the results obtained with the new tuberculin have not proved better than those with the older preparation. The only form of tuberculosis which seems to be decidedly benefited by either the old or the new tuberculin is lupus. Relapses, however, are common.

The chief use to which tuberculin has been put is as an aid to the diagnosis of obscure cases of tuberculosis in cattle and man, and for this purpose it has proved to be of inestimable value. Cows are generally injected subcutaneously with 0 3 to 0.5 c.c. (diluted with water to 30 or 50 c.c.) of tuberculin and watched to see whether there is a rise of temperature of 1.5° to 3° C. in twelve to fifteen hours. Occasionally the reaction does not occur when the animals are in an advanced stage of the disease, but in such cases the test is not needed. The reaction never takes place, or one very much less marked occurs, in healthy animals, though small centres of infection are often difficult to locate later on autopsy. Latent tuberculosis is rarely if ever stimulated to renewed activity. It is important to note that an animal frequently requires an interval of a month to give a second positive reaction, if it has reacted typically on the first trial. In man it is, of course, much more difficult to form any opinion as to the reliability of the tuberculin test, from the fact that it cannot be controlled by post-mortem examinations; at any rate this test in man is at present not used extensively for diagnostic purposes.

Maragliano and others claim to have obtained with an antituberculous serum, prepared chiefly from horses, encouraging results; and Behring hopes soon to be able to make an antitoxic serum which will be curative and protective. But whether serum therapy is destined to solve the problem of the treatment of tuberculosis remains for the future to decide. Judging, however, from the progressive nature of the disease, there is not much ground to hope for the abundant development of curative substances in the blood of animals.

Meanwhile all energies should be directed to the prevention of tuberculosis, not only by the enforcement of proper sanitary regulations as regards the care of sputum, milk, meat, disinfection, etc., but also by continued experimental work and by the establishment of consumptive hospitals; and by efforts to improve the character of the food, dwellings, and condition of the people in general we should endeavor to build up the individual resistance to the disease. It may be years yet before the public are sufficiently educated to co-operate in adopting the necessary hygienic measures to stamp out tuberculosis entirely; but from the results which have already been obtained in reducing the mortality from this greatest scourge of the human race, we have reason to hope that in time it may be completely eradicated.

THE LEPROSY BACILLUS (*Bacillus Lepræ*).—This organism, discovered by Hansen in 1879, is found chiefly in the interior of the peculiar round and oval cells met with in leprous tubercles. The bacilli have also been observed in the lymphatic glands, liver, spleen, and testicles, and in the thickened portions of nerves involved in the anæsthetic forms of the disease. According to some authorities they occur likewise in the blood. The bacilli lie in the leprous cells in great numbers, and also in the lymph spaces outside of these cells. They are not found in the epidermal layers of the skin, but, according to Babes, they may penetrate the hair follicles.

Microscopical Appearances.—The bacillus lepræ resembles the tubercle bacillus in form, but is somewhat shorter and not so frequently curved. The rods have pointed ends; and in stained preparations, unstained spaces, similar to those observed in the tubercle bacillus, are seen. (See Plate X., Fig. 2.)

Motility.—Non-motile.

Staining Reactions.—The leprosy bacillus cannot be positively differentiated from the tubercle bacillus by staining reactions. It stains readily with the aniline colors and also by Gram's method. Although differing from the tubercle bacillus in the ease with which it takes up the ordinary aniline dyes, it behaves like the former in the manner in which it retains its color when subsequently treated with strong solutions of the mineral acids and alcohol. Inasmuch as leprosy and tuberculosis not infrequently occur together in the same person (according to Hansen and Looft tuberculosis being the cause of death in forty per cent. of the cases of leprosy), in making a differential diagnosis, all the various points must be considered, histological and pathological, and animal inoculations made, in addition to microscopical examination.

Biological Characters.—Attempts to cultivate the bacillus lepræ have frequently been made, but so far with only questionable results, as none of the cultures obtained has produced a similar disease when inoculated into animals. The etiological relation of this bacillus to leprosy is based, therefore, chiefly upon its constant presence in the leprous tissues. It has been shown by Spronk, however, that the blood serum of many lepers even in weak dilution gives the agglutinating reaction with cultures of the bacillus lepræ,—a fact which goes to prove that the organism cultivated is the true cause of the disease with which it is associated.

Pathogenesis.—Some investigators claim to have had positive results in inoculation experiments on animals with portions of leprous tubercles, excised for the purpose; but none has succeeded in producing the typical lesions of the disease as seen in man. Arning inoculated a condemned criminal in the Sandwich Islands with fresh leprous tubercles, his death occurring from leprosy five years later; but there is no conclusive evidence of the transmissibility of the disease in this way, as the man, according to Swift, had other opportunities for becoming infected.

It is generally assumed that infection takes place through the mucous membranes and through slight skin wounds. There is said to be no infection by way of the digestive tract. With regard to the question of direct inheritance from the mother to the unborn babe, there is considerable difference of opinion. Some cases of intra-uterine infection have been reported, but they are at least very rare. Leprosy bacilli are frequently present in the spermatic fluid and in the milk, but they have never been found in the ovaries. Most commonly they are met with in purulent nasal secretions (one hundred and twenty-eight out of one hundred and fifty-three cases examined by Sticker), and in the mucous membranes of the mouth, throat, etc.; but they have also been found in various other organs of the body, in the nerves, and in the blood. The widespread opinion, which was held before the discovery of the leprosy bacillus, that the disease was associated in some way with the eating of certain kinds of food, as salt fish, has now been generally abandoned. The negative results obtained from inoculation experiments, together with the fact that infection is not readily transmitted to persons exposed to the disease, have been explained by the assumption that the bacilli contained in the leprous tissue are mostly dead and non-virulent; but it is much more probable that a special susceptibility to the disease, inherited or acquired, is requisite for its production.

The great similarity in many respects of leprosy to tuberculosis has recently been still more emphasized by the observations of Babes and Kalindero, who state that leprosy reacts, both locally and generally, to an injection of tuberculin in the same manner as tuberculosis.

THE SMEGMA BACILLUS (*Bacillus Smegmatis*).—Found by Tavel and Matterstock in the smegma præputii, between the scrotum and thigh and between the labiæ; also in the cerumen and occasionally on the skin. The bacilli lie in clusters either in or between the epithelial cells, the rods being very similar, in size and form, to those of the tubercle bacilli. They stain with difficulty, and resist decolorization with acid when stained by the methods for staining the tubercle bacillus, but are decolorized when treated for one minute with absolute alcohol. This bacillus is most likely to be mistaken for the tubercle bacillus in the examination of urine.

LUSTGARTEN'S BACILLUS OF SYPHILIS.—This organism, which very closely resembles the tubercle bacillus and the smegma bacillus, was found by Lustgarten (1884) in the secretions of syphilitic ulcers and believed by him to be the specific cause of syphilis. Doutrelepont about the same time also observed a similar organism and came to a like conclusion.

Lustgarten's bacillus, though morphologically similar to the bacilli above mentioned, differs from them in staining reactions. It stains with equal difficulty as the tubercle bacillus, but is much less resistant to the action of acids; it is also more resistant, as a rule, to the decolorizing action of alcohol than is the smegma bacillus.

Numerous attempts have been made to cultivate this bacillus artificially but without success. The inoculation of animals with syphilitic tissues and secretions has also given only negative results, though in man, as is well known, infection by inoculation frequently takes place, the tertiary lesions only being non-infectious.

Lustgarten's bacillus has been found in various syphilitic tissues, in beginning sclerosis, in the papules, in condylomata and gummata, and not only in the vicinity of the genitals, but also in the mouth, throat, heart, and brain. No satisfactory experimental evidence has been given, however, of its causative relation to syphilis, and though the failure to find other micro-organisms, and the occurrence of these characteristic bacilli in various parts of the body, would seem to point to their etiological importance, on the other hand, the long immunity in this disease (so different from that in any known bacterial affection) casts doubt not only upon the status of Lustgarten's bacillus, but also upon the bacterial nature of the micro-organisms producing it.

Baumgarten, who has searched in vain for Lustgarten's bacillus in uncomplicated visceral syphilomata, suggests that the bacilli found in such lesions were, perhaps, tubercle bacilli, and represented a mixed infection. Other micro-organisms have also been described and claimed to be the cause of syphilis, but none of these discoveries has been corroborated.

Recently (1899) Van Niessen has isolated from the blood and condylomata of syphilitics an organism which presents some of the characteristics of the diphtheria bacillus. This bacillus shows distinct club-like and branching forms and stains with the ordinary aniline dyes, and by Gram's method, but not with carbol fuchsin. It grows slowly on all culture media, developing whitish to yellowish colonies; and is said to be pathogenic for monkeys and pigs. Van Niessen lays particular stress upon the agglutinating reaction of his bacillus with the serum of syphilitic patients.

From this it appears that none of the organisms so far discovered has been conclusively proven to be the true cause of syphilis; and the position of Lustgarten's and Van Niessen's bacilli are at present too doubtful to make their detection of any diagnostic value.

THE INFLUENZA BACILLUS (*Bacillus Influenzæ*).—Discovered by Pfeiffer and isolated in pure cultures (1891-92) from the purulent bronchial secretions of patients suffering from epidemic influenza. Pfeiffer's discovery has been fully confirmed by others, the results of whose researches give us reason to believe that this bacillus is the chief etiological factor in the production of influenza or "la grippe."

Microscopical Appearances.—Extremely small, moderately thick bacilli, about two or three times as long as broad, with rounded ends, occurring singly or in pairs,

but threads or chains of three or four elements are occasionally met with in cultures; often found in the interior of cells. (See Plate X., Fig. 3.)

Motility.—Non-motile.

Spore Formation.—Does not form spores.

Staining Reactions.—The influenza bacillus stains with difficulty with the ordinary aniline colors; best with dilute Ziehl's solution of carbol fuchsin or Loeffler's methylene blue solution, with heat. When faintly stained the two ends of the bacilli are somewhat more deeply stained than the middle portion. It does not usually stain with Gram's solution, though some investigators report such staining reaction.

Biological Characters.—Strictly aërobic; no growth occurs below 26° C., or above 43° C., or in the entire absence of oxygen; optimum temperature, 37° C. Grows on the surface of solid nutrient media containing hæmoglobin or pus cells, as *blood agar* or *blood serum*. At the end of eighteen to twenty-four hours on such culture media in the incubator very small, drop-like colonies are developed, which under a low magnification appear as shining, transparent, homogeneous masses; older cultures are sometimes colored yellowish brown in the centre. A characteristic feature of the growth of the influenza bacillus is that the colonies tend to remain separate, although when thickly sown in a film of moist blood upon nutrient agar they may occasionally become confluent. Spread out in a thin layer upon the surface of blood bouillon the growth develops as delicate white flakes. According to Grassberger a mixture of nutrient agar and defibrinated blood, which has been kept for one hour at 50° to 60° C., makes an especially good soil for their growth.

Vitality.—The influenza bacillus is very sensitive to desiccation; a pure culture diluted with water and dried is destroyed with certainty within twenty-four hours. In dried sputum vitality is retained for from twelve to twenty-four hours, according to the degree of drying. It does not grow, but soon dies in water. The thermal death point is 60° C. with five minutes' exposure. In bouillon cultures at 20° C. the bacilli remain alive for from a few days to two or three weeks.

Pathogenesis.—The bacillus of influenza, so far as is known, produces the disease by artificial infection only in monkeys and rabbits. From numerous experiments made in guinea-pigs, rats, mice, and pigeons these animals seem to be immune to influenza. When a small quantity of a twenty-four-hour-old culture on blood-agar is injected intravenously into rabbits, Pfeiffer found that a characteristic pathogenic effect was produced. Within one and one-half to two hours after the infection, the animals became very feeble, and suffered from dyspnœa, the temperature rising to 41° C. or more. At the end of five or six days they were able to sit up and move about again, and later they recovered. Larger doses caused death. When cultures were rubbed into the nasal mucous membranes of monkeys, these animals showed a febrile condition, lasting for a few days, but in no instance has Pfeiffer observed a multiplication of the bacilli introduced, the results being due to toxic products. Recently Cantani has shown that it is possible to produce an infection of influenza in rabbits when inoculated with small doses (.25 to .5 c.c.) of living bacilli, provided the point of least resistance is chosen, viz., the brain, the toxic products of the influenza bacillus acting most powerfully upon the central nervous system. The cell bodies of the bacilli seem to possess considerable pyogenic action.

It is possible that an *immunity* against the influenza poison lasting for a short period may be established after an attack. At least in three experiments made by Pfeiffer on monkeys, these animals, after recovering from an inoculation, seemed to be less susceptible to a second injection.

The influenza bacillus has not been found outside of the body. In patients suffering from influenza the bacilli are chiefly met with in the nasal and bronchial secretions, more especially in the characteristic light yellowish to green purulent sputum. The older the process the fewer bacilli will be found, and the more frequently will they be seen lying within the pus cells. At this time they stain less readily and present more irregular and swollen forms. Very often, perhaps almost invariably, the process invades portions of the lung tissue. In severe cases a kind of lobular pneumonia results, and is accompanied by symptoms almost identical with broncho-pneumonia. In fatal cases the bacilli have been found to have penetrated not only into the peribronchial tissue, but even to the surface of the pleura. The pleurisy which follows influenza, however, is usually a secondary infection, due to the streptococcus or pneumococcus. Ordinarily the disease runs an acute or subacute course, and not infrequently it is associated with a mixed infection of the pneumococcus or streptococcus. But sometimes a chronic condition may be produced depending upon the influenza bacillus; the bacilli remaining latent for a while and then becoming active again, with a resulting exacerbation of the disease. Phthisical patients are particularly susceptible to attacks of influenza. It would appear, therefore, that given proper climatic conditions, we have at all times the seeds of influenza present in sufficient numbers to start an epidemic.

The discovery of this bacillus enables us to explain many things previously unaccountable in the cause of epidemic influenza. We now know from the fact that the bacillus cannot exist for any considerable length of time in water or in dust, that the disease is not transmissible to great distances through these means. We also know that the infective material is contained chiefly in the catarrhal secretions. The occurrence of sporadic cases, or the sudden eruption of an epidemic in a locality from which the disease has been long absent, and where there has been no new importation of infection, may possibly be explained by the supposition, as already noted, that the influenza bacilli remain latent in the air passages of certain individuals for months at a time, and then become active under conditions favorable for their growth, when the infection may be communicated to others in close contact with them. The bacteriological diagnosis of influenza is of considerable importance for the identification of clinically doubtful cases, which from the symptoms may be mistaken for other diseases, such as bronchitis, pneumonia, or tuberculosis.

In acute uncomplicated cases the probable diagnosis can be frequently made by microscopical examination of stained preparations of the sputum, there being present enormous numbers of the small bacilli. In chronic cases or those of mixed infection the culture method must usually be employed if we wish to arrive at positive results. The bacillus of influenza is so well characterized by its morphological, staining, and cultural peculiarities that it may be distinguished from all other bacteria by an expert bacteriologist with sufficient certainty for diagnostic purposes. The only bacillus which at all closely resembles it is the *pseudo-influenza bacillus* found by Pfeiffer in three cases of broncho-pneumonia; and this is distinguished from the genuine influenza bacillus by its larger size and tendency to grow out, in cultures on blood agar, into long threads.

THE DIPHTHERIA BACILLUS (*Bacillus Diphtheriæ; Klebs-Loeffler Bacillus*).—This bacillus was first observed by Klebs (1883) in diphtheritic false membrane. It was isolated in pure cultures and its pathogenic properties demonstrated by Loeffler in 1884. In 1887–88 further studies by Loeffler, Roux, and Yersin added to the proof of the dependence of diphtheria upon this bacillus. The results of these investigations have since been confirmed by a great number of combined clinical and bacteriological observations both in animals and man. All the conditions have been fulfilled for diphtheria which are necessary to the most vigorous proof of the causative relation of a given micro-organism to an infectious disease, viz., the constant presence of the organism in the lesions of the disease, the isolation of it in pure culture, the failure to produce the disease by any other bacteria, and the additional demonstration of the immunizing value of

the specific antitoxic substances developed in animals subjected to injections of diphtheria toxin. In view of these facts we are justified in concluding that all cases of true or primary diphtheria are due to the Klebs-Loeffler bacillus.

Microscopical Appearances.—Somewhat slender rods of variable size, 1 to 6 μ long and 0.5 to 1 μ broad, either straight or slightly curved, with rounded ends, occurring singly or in pairs. Irregular forms are very common, and indeed are characteristic of this bacillus. In the same culture and in unfavorable media great differences in form and dimensions occur; one or both ends may appear swollen, or the central portion may be thicker than the extremities, or the rod may consist of irregular spherical or ovoid segments. The rods sometimes lie in clusters alongside of one another in a characteristic manner, like a bundle of fagots. Threads with swollen ends and branching forms sometimes occur, but these are comparatively rare. (See Plate X., Fig. 4.)

Motility.—Non-motile.

Spore Formation.—Absent, but cultures retain their vitality for months.

Staining Reactions.—Stain readily with the ordinary aniline dyes and retain fairly well their color after staining by Gram's method. When Loeffler's alkaline solution of methylene blue is applied cold for five minutes or warm for one minute, the bacilli from blood-serum cultures especially, and from other media less constantly, stain in an irregular and extremely characteristic way. Carbol fuchsin and gentian violet stain the bacilli too intensely, obscuring the structure of the organisms.

Neisser has recently described a double stain which brings out the metachromatic bodies of the diphtheria bacillus, and which he claims may be used as a method of differential diagnosis between the virulent and non-virulent diphtheria bacilli without the delay of inoculating animals. The cover-slip smear of diphtheria bacilli is placed for two or three seconds in a solution composed of alcohol (96 per cent.) 20 parts, methylene blue 1 part, acetic acid (glacial) 50 parts, and distilled water 950 parts, and then, after washing, in a second solution (for from three to five seconds) composed of Bismarck brown 1 part, and boiling distilled water 500 parts. By this method the bacilli are usually stained brown and at one or both ends a blue granule is seen; while the non-virulent bacilli ordinarily are not so stained. But sometimes the pseudo-diphtheria bacilli show the same dark bodies, and occasionally the virulent bacilli fail to take the Neisser stain. Neither this nor any other stain, therefore, can be depended upon to give positive information as to the virulence of the bacilli, the only certain way of obtaining a differential diagnosis between the pseudo- and true diphtheria bacilli being by animal inoculations with control injections of antitoxin. (See Plate X, Fig. 5.)

Biological Characters.—Aërobic and facultative anaërobic; grows best in the presence of oxygen, but also less readily without it. Development is good and abundant only at 37° C., the extremes being 20° and 41° C. It grows on all the ordinary culture media, glycerin agar being a favorable medium, though blood serum and ascitic fluid are still better. Loeffler's blood-serum mixture (see *Micro-Organisms: Technology*) is much used and is the best culture medium for diagnostic purposes in examining cultures from the throats of persons suspected of having diphtheria. The growth in gelatin at 22° to 24° C. is not characteristic, and is so scanty that it is seldom employed for the cultivation of the diphtheria bacillus. The gelatin is not liquefied.

Growth on Blood Serum.—On Loeffler's blood-serum mixture at the end of eight to twelve hours small colonies develop which appear as pearl gray, or more rarely yellowish gray, slightly elevated points. The borders are usually uneven. After forty-eight hours the colonies when separated may so increase in size that they are one-eighth of an inch in diameter; these lying close together become confluent and fuse into one mass, if the serum be moist. During the first twelve hours the colonies of the diph- bacilli are about equal in size to those of other pathogenic bacteria which are often present in the throat; but after this time the diphtheria colonies become larger than those of the streptococci and smaller than those of the staphylococci. The blood serum is not liquefied.

Growth on Agar.—On one-per-cent. slightly alkaline, nutrient or glycerin agar the growth of the diphtheria bacillus is less certain and luxuriant than upon blood serum, but the appearance of the colonies when examined under a low-power lens is often more characteristic; the growth, however, is variable, and when obtained fresh from pseudo-membranes the colonies develop slowly or fail to develop at all. On *agar plates* the deep colonies are usually round or oval and as a rule present no extensions, but the surface colonies commonly from one and sometimes from both sides spread out an apron-like extension which exceeds in area the rest of the colony. These surface colonies are more or less coarsely granular in structure and usually have a dark centre. Some are almost translucent, others are thick and luxuriant with irregular borders shading off into a delicate lace-like fringe, though sometimes the margins are more even and the colonies are nearly circular. With a high-power lens the edges show sprouting bacilli, the colonies being gray or grayish white by reflected light and pure gray with olive tint by transmitted light. A mixture composed of two parts of a one and one-half per cent. nutrient agar and one part of sterile ascitic fluid makes a medium upon which the bacillus grows much more luxuriantly but not so characteristically. Nutrient plain or glycerin agar, with or without the addition of ascitic fluid, is the medium employed for the isolation of the diphtheria bacillus by plate methods from the original serum tube. The agar should be freshly melted and poured into the Petri dish for this purpose, and after it has hardened *streak cultures* from the colonies on blood serum are made upon this, the plates being left in the incubator at 37° C. for twelve hours.

Growth on Gelatin.—The growth on gelatin is much slower and more scanty than that on blood serum or agar, on account of the lower temperature at which it is used. Gelatin is not liquefied.

Growth in Bouillon.—In slightly alkaline or neutral bouillon the diphtheria bacillus grows in fine grains, which are deposited along the sides and on the bottom of the tube, leaving the broth nearly clear. Sometimes the bouillon may appear diffusely clouded to the naked eye, but when examined microscopically in the hanging drop the clumpy arrangement is readily observed. Frequently a whitish film forms over part of the surface, but in shaking this breaks up and slowly sinks to the bottom. This film is more apt to develop in cultures which have been long cultivated in bouillon. The reaction of the bouillon is subject to changes—the diphtheria bacillus in its growth causes a fermentation of the meat sugars with the production of acid; hence the bouillon becomes at first acid and subsequently alkaline, when the fermentable sugars have been decomposed, this latter change being favored by the admission of air.

Growth in Milk.—The diphtheria bacillus grows readily in milk, beginning to develop at a comparatively low temperature (20° C.). Thus milk having become inoculated with the bacillus from a case of diphtheria may under certain circumstances be the means of conveying infection to previously healthy persons. The growth takes place better in raw than in boiled milk. The milk is not coagulated, remaining unchanged in appearance, but the cultures may retain their vitality for a long time.

On *potato* which is rendered alkaline a delicate coating develops.

Vitality.—Virulent diphtheria bacilli may persist in the throats of convalescents from diphtheria, after the disappearance of the false membrane, for weeks and months even. In 304 of 605 consecutive cases of diphtheria examined by Park and Beebe the bacilli were found to be no longer present within three days after the disappearance of the false membrane; in 176 cases they persisted for seven days, in 64 cases for twelve days, in 36 cases for fifteen days, in 12 cases for three weeks, in 4

cases for four weeks, in 2 cases for nine weeks, and recently a case has been noted in which the virulent bacilli were present for six months. The practical importance of this fact is the evident necessity for the isolation of convalescents from diphtheria, whether showing clinical symptoms or not, until all the Klebs-Loeffler bacilli have disappeared from the throat.

In cultures kept in a cool, dark place, the bacilli retain their vitality for from six months to a year or more. In the incubator they are generally killed by desiccation in from one to three months; but even here, when the air is excluded, they remain alive in bouillon for a long time. They also retain their vitality for a considerable time in water and articles of food, etc.

The diphtheria bacillus possesses a considerable resistance to desiccation. Pure cultures in saturated silk threads at room temperature remain alive under favorable conditions for months. In dried diphtheritic exudate, even when pulverized, they retain their virulence for a long time. They are soon killed by moist heat at 60° C. Cold has comparatively little influence upon them, and even when dried they retain their virulence in winter for several months. Suspended in water and exposed to the action of direct sunlight the bacilli die in a few hours, but in agar and bouillon cultures they remain alive for six hours.

Chemical Effects.—The diphtheria bacilli produce gas and acids from carbohydrates, as from glucose present in ordinary nutrient bouillon. They also produce sulphuretted hydrogen and indol. In old cultures some nitrites are present, which with the indol give the nitroso-indol reaction on the addition of pure sulphuric acid. Pigment production is rare, though occasionally yellow to reddish species have been met with. Old bouillon cultures of the diphtheria bacillus filtered through porcelain produce the same symptoms as inoculations with the bacilli themselves. Particularly active toxins are obtained, according to von Dungern, by the addition of ascitic fluid to the bouillon. Sugar is to be avoided. Bouillon cultures as long as they are acid contain no toxins. A two-per-cent. peptone nutrient bouillon, having an alkalinity equal to about 8 c.c. of normal soda solution per litre above the neutral point to litmus, is a suitable medium for the development of toxin. Free access of air favors its production. The greatest accumulation of toxin in bouillon is after a growth of from five to ten days in the incubator at 35° to 37° C.

These poisons of diphtheria have been partially isolated. They are precipitated in part by alcohol, calcium phosphate, calcium chloride, and magnesium sulphate. The toxin has not yet been successfully analyzed, so that its chemical nature is unknown. It has many of the properties of proteid substances, but it is formed not only in albuminous culture media but also in those free from albumin. It is not a stable body, being totally destroyed by boiling for five minutes, and losing ninety-five per cent. of its strength when exposed to a temperature of 75° C. for some time. Temperatures under 60° C. alter it only very gradually. It is slowly decomposed when exposed to light and air, but kept in a cold, dark place it may be preserved almost indefinitely. According to Kossel diphtheria toxin is formed in the cell bodies of the bacilli and thence secreted. Ehrlich, who has recently investigated the subject of toxins, subdivides them, according to their degrees of toxicity, into protoxoids, syntoxoids, and epitoxoids.

Pathogenesis.—The diphtheria bacillus is pathogenic for guinea-pigs, rabbits, chickens, pigeons, small birds, and cats; also in a lesser degree for dogs, goats, cattle, and horses, but scarcely at all for rats and mice. True diphtheria, however, as observed in man, is extremely rare among these animals, the so-called diphtheritic inflammations in them being due, as a rule, to other bacteria than the Klebs-Loeffler bacillus.

The virulence of pure cultures of the diphtheria bacillus from different sources, as measured by their toxin production, varies enormously. In general, severe cases of diphtheria yield strongly virulent cultures, and mild cases slightly virulent ones; but there are exceptions to this rule. One of the most virulent cultures so far known —culture No. 8, which is used not only by the New York Health Department Laboratory, but by many other laboratories in the United States and Europe, for the production of toxin—was obtained from an extremely mild case of diphtheria. Experimental and accidental attenuation of the diphtheria bacilli has often been observed. Roux and Yersin maintain that there is a uniform and gradual decrease in virulence of the bacilli found in the throats of convalescents from diphtheria, but this has not been confirmed by others, highly virulent bacilli having been repeatedly found in the throats of those recovering from the disease long after the disappearance of all clinical symptoms. The same marked variation occurs in the amount of toxin produced by different bacilli in their growth in media outside of the body. There are also bacilli which produce no specific toxin whatever and yet appear to have all the other characteristics of virulent bacilli. Moreover, some diphtheria bacilli retain their virulence, when grown in artificial media, much longer than others. The passage of the bacilli through the bodies of susceptible animals does not increase their virulence to any appreciable extent, this being probably due to the fact that they multiply but little in the tissues.

The best guide for the virulence of a diphtheria bacillus is the toxicity of the filtrate of a culture of definite age, as shown by inoculation into guinea-pigs; for this purpose an alkaline broth culture of forty-eight hours' growth is used. The amount injected should not be more than one-fifth per cent. of the body weight of the animal inoculated, unless controls with antitoxin are made. In the large majority of cases, when the bacilli are virulent, this amount causes death within seventy-two hours. For an absolute test of specific virulence antitoxin must be used. A guinea-pig is injected subcutaneously with antitoxin, and then this and a control animal are injected with double the fatal dose of a broth culture of the bacilli to be tested. If the animal which received the antitoxin lives, while the control animal dies, it was surely a virulent diphtheria bacillus which killed by means of the toxin produced.

About twenty-four hours after the subcutaneous inoculation of a virulent culture of the diphtheria bacillus the animal becomes languid, has no appetite, its hair is rumpled, its nose cold and blue, and its respiration rough; the point of injection is infiltrated, sometimes also the surrounding tissues. Certain symptoms, however, exclusive of loss of weight, may be wanting. On autopsy there will be found at the seat of inoculation a grayish deposit surrounded by an area of congestion; the subcutaneous tissues for some distance around are œdematous; the adjacent lymphatics are swollen, and the serous cavities, especially the pleural and the pericardial, frequently contain an excess of fluid, usually clear, but at times turbid; the lungs are generally congested. In the organs are found numerous smaller or larger masses of necrotic cells, which are permeated with leucocytes. The heart and voluntary muscular fibres usually show degenerative changes. Occasionally there is fatty degeneration of the liver and kidneys. From the area surrounding the point of inoculation virulent bacilli may be obtained, but in the organs they are only occasionally found, unless an enormous number of bacilli have been injected. Paralyses, commencing generally in the posterior extremities and gradually extending to other portions of the body and causing death by cardiac paralysis or paralysis of the respiratory organs, is also produced in many cases in which the inoculated animals do not succumb to a too rapid intoxication. In rare instances the muscles of the neck or of the larynx are first paralyzed and thus characteristic symptoms are produced.

Rabbits are much less susceptible to subcutaneous inoculation than guinea-pigs; white mice and rats are almost immune. On the other hand, cats, dogs, cows, and horses are susceptible, as are also young pigeons and chickens, and small birds.

EXPLANATION OF
PLATE X.

EXPLANATION OF PLATE X.

FIG. 1.—Bacillus Tuberculosis in Sputum. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 2.—Bacillus of Leprosy. Section of Skin Nodule. × 1,000. Photomicrograph from Bowhill's "Bacteriology" by permission.

FIG. 3.—Bacillus of Influenza in Bronchial Mucus. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 4.—Bacillus of Diphtheria (Klebs-Loeffler). Blood-serum culture stained with Loeffler's solution of methylene blue. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 5.—Bacillus of Diphtheria. Stained with Neisser's solution, showing bodies of bacilli in smear faint brown; points, dark blue. × 1,000. Photomicrograph from Park's "Bacteriology" by permission.

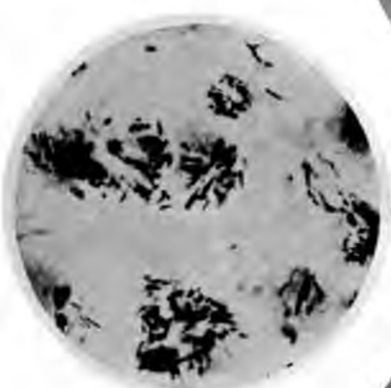
FIG. 6.—Pseudo-Diphtheria Bacillus, Small Type. × 1,000. Photomicrograph from Park's "Bacteriology" by permission.

FIG. 7.—Bacillus of Typhoid Fever, from Agar Culture. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 8.—Bacillus of Typhoid Fever with Flagella. Agar culture. × 1,000. Photomicrograph from Bowhill's "Bacteriology" by permission.

Plate X.

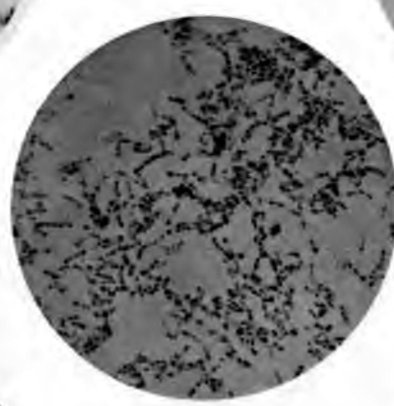
I.
Tubercle Bacilli in Sputum.



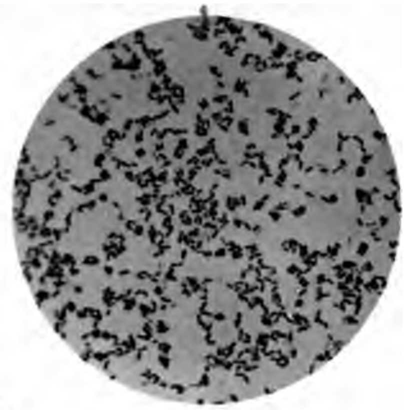
II.
Leprosy Bacillus.

III.
Influenza Bacillus.

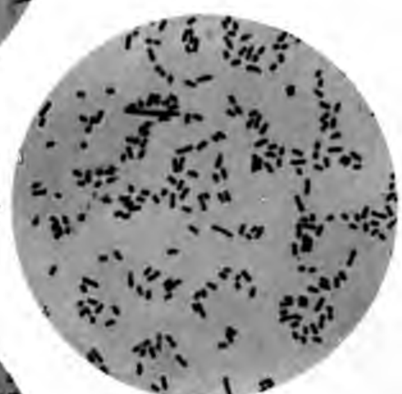
IV.
Diphtheria Bacillus.
(Blood-serum Loeffler's Methylene-blue stain).



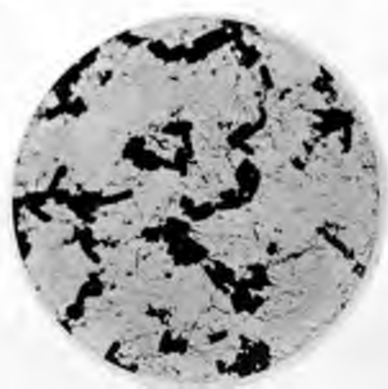
V.
Diphtheria Bacillus.
(Neisser Stain).



VI.
Pseudo-diphtheria Bacillus,
(Small Type).



VII.
Bacillus of Typhoid Fever.



VIII.
Bacillus of Typhoid Fever with Flagella.

Pathogenic Bacteria.

Diphtheritic false membrane, analogous to human diphtheria, may be produced in animals by rubbing in diphtheria bacilli on the slightly abraded surface of mucous membranes of the trachea and conjunctiva of rabbits, of the throats of monkeys, and of the pharynx and larynx of pigeons and chickens. The process remains local. According to Loeffler, the best results are obtained by inoculation of the vaginal mucous membranes of guinea-pigs.

In man no experimental inoculations have been made, but in two involuntary laboratory experiments made in the New York City Health Department severe diphtheria was contracted by inadvertently sucking up virulent bouillon cultures of the diphtheria bacillus into the mouth.

Outside of the body diphtheria bacilli have been found upon articles used by diphtheria patients, as upon linen, brushes, toys, walls and floors of rooms, etc., and in the hair of nurses. The air (exclusive of momentary contamination through the coughing of patients) never contains the bacilli. They have also been found at times in the throat and nasal cavities as well as in the conjunctiva of healthy individuals, especially of those coming in contact with diphtheria patients. Out of three hundred and thirty healthy persons who had not been in contact, so far as known, with cases of diphtheria, Park and Beebe found virulent bacilli in eight only, two of whom later developed the disease. It is evident, therefore, that infection from diphtheria, as in other infectious diseases, requires not only the presence of virulent bacilli in the throat, but also an individual susceptibility at the time to the disease. Among the predisposing factors which may contribute to the production of diphtheria are the breathing of foul air and living in over-crowded and ill-ventilated rooms, poor food, and certain other affections, more especially catarrhal inflammations of the mucous membranes, but all depressing conditions in general favor the development of the disease.

The chief locations of the bacilli in diphtheria are on the surface of the pseudo-membranous inflammations of the fauces, larynx, and nasal cavities, but also occasionally in membranous affections of the skin, vagina, rectum, conjunctiva, nose, and ear (membranous rhinitis and otitis media). Occasionally they have been found in the blood and interior organs (spleen and kidneys).

Almost always the streptococcus pyogenes is associated with the diphtheria bacillus, with which it acts pathologically as a synergist. Regarding the importance of *mixed infection* in diphtheria, Bernheim has stated that the streptococcus products of decomposition favor the growth of the diphtheria bacilli and increase their virulence for production of toxin. Nevertheless, the diphtheria bacillus alone undoubtedly may produce all the clinical symptoms of sepsis.

Non-Virulent Diphtheria Bacilli.—There are sometimes found in inflamed throats as well as in healthy throats, either alone or associated with virulent diphtheria bacilli, micro-organisms which though morphologically and biologically identical with the Klebs-Loeffler bacillus, appear to be non-virulent—that is, in artificial culture media and with the usual animal tests they produce no appreciable diphtheria toxin. Between the bacilli which produce a great deal of toxin and those which seem to produce none at all we find all grades of virulence. These are probably attenuated varieties of the diphtheria bacillus which have lost their power of producing toxin (Roux and Yersin). Bacilli are also found which resemble the Klebs-Loeffler bacilli very closely except in toxin production, but differ also in some other respects. From varieties of this kind having been found in a number of cases of so-called *xerosis conjunctivæ* these bacilli are often designated as *xerosis bacilli*. They are usually much larger than diphtheria bacilli and have club-like extremities. They may be almost non-pathogenic for guinea-pigs, or they may kill. Animals are not protected by diphtheria antitoxin from the action of these bacilli. Whether they are derived from the original diphtheria stock is not known.

Pseudo-Diphtheria Bacilli.—Besides the typical bacilli which produce diphtheria toxin and those which do not, but which, so far as we can determine, are otherwise identical with the Loeffler bacillus, there are other bacilli found in positions similar to those in which diphtheria bacilli occur, and yet, though resembling these organisms in many particulars, differ from them in certain important characteristics. The variety most prevalent is rather short, plump, and more uniform in size and shape than the true Loeffler bacillus, and the great majority of them in culture show no polar granules when stained by the Neisser method, staining evenly throughout with Loeffler's alkaline methylene blue solution. Their colony growth on blood serum is very similar to that of the diphtheria bacilli, but they do not produce acid by the fermentation of glucose, and they never produce diphtheria toxin. These are properly called *pseudo-diphtheria bacilli*. When found in cultures from cases of suspected diphtheria they may lead to an incorrect diagnosis; and here the Neisser method of staining is of value, though the only absolute test of virulence is by inoculation of susceptible animals. (See Plate X., Fig. 6.)

Pseudo-Membranous Inflammations due to Bacteria other than the Diphtheria Bacilli.—The diphtheria bacillus, though the most usual, is not the only micro-organism that is capable of producing pseudo-membranous inflammations. The streptococcus, staphylococcus, and pneumococcus are the forms most often found in angina simulating diphtheria, but there are also others which, under suitable conditions, take an active part in producing this kind of inflammation. But the bacteria which occur in this so-called *false diphtheria* are all morphologically and culturally distinct from the Loeffler bacilli.

Susceptibility and Immunity.—It is now commonly recognized that an individual susceptibility, both general and local, to diphtheria is necessary to contract the disease. Age has long been known to be an important factor in the production of diphtheria, children within the first six months of life being but little susceptible, most so between the third and tenth years, while adults are comparatively immune. An apparent inherited susceptibility to the disease has also been observed. Two attacks of diphtheria have rarely been known to occur in the same individual within a short time. But to what this natural susceptibility or immunity is due is as yet only partially understood. As the result of animal experiments, however, it has recently been shown that an artificial immunity against diphtheria can be produced, at least for a considerable period, by the development, in the body, of substances antidotal to the diphtheria toxin.

Animals may be immunized against the diphtheria bacillus in various ways: By treatment first with slightly virulent and then with highly virulent cultures of the bacillus; by injection of small quantities of attenuated cultures or of toxin, and then with gradually increasing doses; by injection of the blood serum of animals immunized in one of the above ways against diphtheria. In the earlier experiments on immunization against diphtheria the names of Fraenkel, Wernicke, Aronson, Roux, and others are conspicuous; but to Behring and Kitasato belongs the credit of the fundamental discovery that the blood serum of an animal immunized for certain infectious diseases may be employed for protective inoculations, and that in larger quantity it may even exercise a curative influence after infection has occurred. This is one of the greatest discoveries in scientific medicine of recent years, and the practical results obtained in the treatment of diphtheria, at least, have justified all the expectations that were entertained regarding it. The mortality of this fatal malady among children has been reduced fifty per cent. or more in places where diphtheria was prevalent and where the treatment was continuously and uniformly employed. As to immunity, it stands to reason that a disease which can attack the same person more than once within a comparatively short time does not belong to the class of affections producing a permanent immunity after recovery. It is, however, well known that a certain temporary immunity is thus conferred, and the blood serum

of persons during convalescence from diphtheria has been found to possess immunizing properties. The protection afforded by artificial immunization, therefore, does not last usually more than three or four weeks, but this is usually sufficient to tide over the period of exposure to infection, and if necessary repeated immunizing injections of the antitoxic serum may be given. Regarding the curative injections, the earlier the remedy is administered the more certain and rapid is the effect produced—this effect being, indeed, one of immunity or protection against further infection or absorption by the system of the diphtheria toxin, rather than of neutralization of the poisons already absorbed.

Preparation of Diphtheria Antitoxin.—The principal steps in the preparation of diphtheria antitoxic serum are the production of toxin, the immunization of the horses, and the testing of the antitoxin obtained from them. The following is the method in brief now employed in the laboratories of the Health Department of New York City: The strongest diphtheria toxin possible is obtained by taking a very virulent bacillus and growing it under the conditions already described. The culture, after a week's growth, is removed, and having been tested for purity is rendered sterile by the addition of ten per cent. of a five-per cent. solution of carbolic acid. This sterile culture is then filtered through ordinary sterile filter paper and stored in full bottles in a cold place until needed. Its strength is tested by giving a series of guinea-pigs carefully measured amounts injected subcutaneously. Less than 0.01 c.c., administered hypodermatically, should kill a 250 gm. guinea-pig. The horses used for immunization should be young and absolutely healthy. A number of such animals are severally injected with an amount of toxin sufficient to kill 5,000 guinea-pigs of 250 gm. weight (about 20 c.c. of strong toxin), the point of injection being usually under the skin of the neck or behind the shoulder. After an interval of from three to five days, so soon as the febrile reaction has subsided, a second subcutaneous injection of a slightly larger dose is given. With the first three injections of toxin 10,000 units of antitoxin are administered. If antitoxin is not mixed with the toxin only one-tenth of the doses above mentioned is to be given. At the end of about two months, increasing doses of pure toxin having been injected every five to eight days, from ten to twenty times the original amount is administered. In about three months the antitoxic serum drawn from the horses should contain at least 300 antitoxin units, when tested, and the best of them from 800 to 1,000 units, in each cubic centimetre. Very few horses ever yield over 1,000 units, and none so far has given as much as 2,000 units per cubic centimetre. If every nine months an interval of three months' freedom from inoculations is given, the best horses continue to furnish high-grade serum during their periods of treatment for from two to four years.

In order to obtain the serum the blood is withdrawn from the jugular vein by means of a sharp-pointed cannula, which is plunged through the vein wall, a slit having been made in the skin. It is run into large flasks through a sterile rubber tube, and then allowed to clot, the flasks having been previously placed in a slanting position. From these the serum is drawn off after four days by means of sterile glass and rubber tubing, and is stored in large bottles, small vials being filled as needed for use. Every possible precaution should, of course, be taken in the preparation of the serum to avoid contamination. An antiseptic may be added to the serum as a preservative, but it is not ordinarily necessary. Kept from access of air and light and in a cold place, it is fairly stable, deteriorating not more than forty per cent., and often much less, within a year. When stored in vials and kept as above, diphtheria antitoxin contains within ten per cent. of its original strength for at least two months.

Diphtheria antitoxin has the power of neutralizing diphtheria toxin, so that when a certain amount is injected into an animal before or together with the toxin it overcomes its poisonous action. This power is utilized in testing antitoxin. Guinea-pigs of about 250 gm. weight are subcutaneously injected with one hundred or with ten fatal doses of toxin which have been previously mixed with an amount of antitoxin believed to be sufficient to protect from the toxin. If the guinea-pig lives four days, but dies soon after, the amount of antitoxin added to the toxin was just 1 or 0.1 unit, according as one hundred or ten fatal doses were employed. If the animal dies earlier, less than 1 unit was added. An antitoxin unit has thus been defined as "ten times the amount of antitoxic serum required to protect a guinea-pig weighing 250 gm. from death, when ten times the fatal dose of toxin is mixed with the serum and the mixture injected subcutaneously into the animal."

The Use of Diphtheria Antitoxin in Treatment and Immunization.—For the injection a hypodermic syringe is employed, holding 10 to 12 c.c., which must be previously thoroughly sterilized with alcohol and a five-per-cent. solution of carbolic acid. The injection is made at some point on the anterior surface of the body, as the abdomen or thorax or outer surface of the thigh, where there is an abundance of subcutaneous cellular tissue. Before injection the skin should be carefully washed with alcohol or some disinfecting solution. The serum is rapidly absorbed, and it is better not to employ massage over the point of injection. For treatment of mild cases of diphtheria the dose is 1,500 antitoxin units, for moderate cases 2,000 units, and for severe cases 3,000 units. When no improvement follows in twelve hours the dose should be repeated; sometimes 6,000 units or more may be required in a single case. For immunization of children or adults who have been exposed to diphtheria the dose is from 300 to 500 units, according to age, to be repeated if necessary at the end of two or three weeks. In all cases it is better to use a small quantity of a high-grade serum than a large quantity of a low-grade preparation, as there is in the former instance less danger of rashes and other deleterious effects. The only untoward results to be feared in any case in which proper aseptic precautions are taken in the injection, are occasional rashes with perhaps some slight rise of temperature. In suspicious cases of any severity, particularly in croup, it is better to administer the remedy at once, making a culture at the same time for bacteriological diagnosis, than to delay treatment until a positive diagnosis has been made by bacteriological examination.

THE BACILLUS OF TETANUS (*Bacillus Tetani*).—Nicolaier in 1884 produced tetanus in mice and rabbits by subcutaneous inoculation of particles of garden earth, and showed that the disease was transmissible by inoculation from these animals to others. Carl and Rattone soon after this demonstrated the infectious nature of tetanus as it occurs in man. Finally, in 1889, Kitasato obtained the bacillus of tetanus in pure culture and described its biological characters.

Microscopical Appearances.—Slender rods with rounded ends, 0.3 to 0.5 μ in diameter by 2 to 4 μ in length, usually occurring singly, but often growing into long threads, especially in old cultures.

Spore Formation.—Forms rounded spores thicker than the cells, occupying one extremity of the rods and giving them the appearance of minute drumsticks. (See Plate XII., Fig. 3.)

Motility—Motile, although not actively so in hanging-drop cultures with exclusion of air; numerous flagella are attached to the bodies of the bacilli. In the spore stage they are non-motile.

Staining Reactions.—Stains with the ordinary aniline dyes, and is not decolorized by Gram's solution. The spores may be demonstrated by double staining with Ziehl's method.

Biological Characters.—When freshly isolated from the animal body, this organism is strictly anaërobic; but by long cultivation at high temperatures it often becomes less sensitive to the presence of oxygen, this cultivation being facilitated by association with certain saprophytic bacteria. Carbone and Pessero have obtained from a

case of rheumatic tetanus in which there was no sign of injury in the bronchial mucous membranes virulent tetanus bacilli, which grew more luxuriantly under aërobic than anaërobic conditions; in pure cultures, however, they proved to be non-virulent. The bacillus tetani does not grow at temperatures below 14° C., though slowly from 20° to 24° C.; best at 37° C., when it rapidly forms spores. It develops in the ordinary nutrient gelatin and agar media of a slightly alkaline reaction. The addition of 1.5 per cent. glucose to the media causes the development to be more rapid and abundant. According to von Hibler, the less pathogenic the organism the more luxuriantly it grows on artificial culture media, and the more energetically it liquefies gelatin. In the animal body its growth is comparatively scanty, and it is usually associated with other bacteria, pure cultures being difficult to obtain. Kitasato's method, which is not always successful, however, consists in inoculating an agar tube with the tetanus material (pus from wounds), keeping this for twenty-four hours or more in the incubator at 37° C., and, after the spores have formed, heating it for about an hour at 80° C. to destroy the associated bacteria. The spores of bacillus tetani are able to survive this exposure, and anaërobic cultures are then made in the usual way, and the tetanus colonies isolated.

Growth on Gelatin.—On gelatin plates the colonies develop slowly, the middle portion being generally of a yellowish-brown color, with numerous threads radiating from the centre; the gelatin is liquefied. In old cultures the entire mass is made up of fine threads, the colonies presenting an appearance not unlike that of the common mould. In gelatin stab cultures the growth exhibits the appearance of a cloudy, linear mass with outgrowths radiating into the medium from all sides. Liquefaction takes place slowly, generally with the production of gas having an unpleasant empyreumatic odor.

Growth on Agar.—The colonies on agar are quite characteristic. To the naked eye they present the appearance of light, fleecy clouds; under a low-power microscope they resemble a tangled mass of threads. The extreme fineness of these threads enables the colonies of the tetanus bacillus to be distinguished from those of other anaërobic bacteria. In stab cultures on agar the growth resembles that of a miniature fir-tree.

Alkaline bouillon is moderately clouded by the growth of the tetanus bacillus. It grows also in *acid culture media*, but itself produces no acid. *Milk* is not coagulated.

Vitality.—The spores of tetanus are very resistant to outside influences, retaining their vitality for months or years in a desiccated condition and not being destroyed in two and a half months when present in putrefying material. They withstand exposure to 80° C. for an hour, but are killed by a temperature of 100° C. in five minutes. They resist the action of five-per-cent. carbolic-acid solution for ten hours, but succumb when acted upon for fifteen hours. The addition of 0.5 per cent. hydrochloric acid to the carbolic solution enables it to kill the spores in two hours. In a solution containing 1 to 1,000 bichloride of mercury, five per cent. carbolic acid and 0.5 per cent. hydrochloric acid, the spores are destroyed in ten minutes.

Chemical Effects.—The tetanus bacillus produces gas in media containing sugar but no acid. It forms sulphuretted hydrogen abundantly and a little indol. It produces powerful toxins, which can be separated from the cultures by filtration. One one-hundredth of a milligram of an eight-day filtered bouillon culture is sufficient, as a rule, to kill a mouse. From this filtrate, however, the active toxin has been obtained in a much more concentrated form. The purified and dried tetanus toxin prepared by Brieger and Cohn was surely fatal to a 15-gm. mouse in a dose of 0.00000005 gm. Reckoning according to the body weight of 75 kgm. or 150 pounds, it would require but 0.00023 gm., or 0.23 mgm., of this toxin to kill a man. Comparing this with other known poisons, the appalling strength of the tetanus toxin can be readily appreciated. For instance, Calmette has found that dried cobra venom requires 0.25 mgm. to kill a rabbit of 4 kgm. weight, and it would thus require, at the same rate, 4.375 mgm. to kill a man of 150 pounds; the fatal dose of atropine for an adult is 130 mgm., of strychnine from 30 to 100 mgm., and of anhydrous prussic acid 54 mgm. The true composition of the tetanus toxin is unknown; it has been shown, however, that it is neither an alkaloid nor an albuminous body. The quantity of toxin produced varies, even when derived from one and the same culture, according to its age, composition, reaction, etc. It is extremely sensitive to the action of light, most chemical agents, and heat. It retains its strength best in the dry state.

Pathogenesis.—Man and almost all domestic animals are subject to tetanus. Among animals those most susceptible are horses, goats, guinea-pigs, and mice, less so rabbits and sheep; dogs, rats, pigeons, and chickens are almost immune. It is worthy of note that an amount of tetanus toxin sufficient to kill a hen would suffice to kill five hundred horses. A mere trace—only as much as remains clinging to a straight platinum needle—of an old culture is often enough to cause the death of mice and guinea-pigs.

On subcutaneous inoculation of virulent tetanus material mice and other susceptible animals show symptoms of typical tetanus in from one to three days. The parts first to be affected are in about one-third of the cases in man, and usually in animals, the muscles lying in the vicinity of the inoculation—for instance, the hind foot of a mouse inoculated on that leg, then the tail, the other foot, the back and chest muscles on both sides, the fore legs, until finally there is a general tetanus of the entire body. In mild cases of infection, or when a dose too small to be fatal has been received, the tetanic spasm may be one-sided or remain confined to the muscles adjacent to the point of inoculation, and result in recovery. There may be no general increase of reflex excitability. In man and horses the local symptoms may be absent, but instead tonic spasms of special muscles: in man, of the muscles of the jaw, and in horses of the muscles of the jaw, neck, and tail. At the point of inoculation in test animals there may be on autopsy a hemorrhagic spot, but no changes here or in the interior organs other than this. A few bacilli may be detected locally with great difficulty, often none at all; apparently showing that the lesions produced are due, not to the multiplication of the bacilli in the living body, but to the absorption of the poison formed by them at the point of inoculation. It has been found that cultures freed from spores, and such as have been subjected to heat at 80° C., after sporulation and the toxins destroyed, can be injected into animals without producing tetanus. But if a culture of non-pathogenic organisms be injected simultaneously with the spores, or if there be an effusion of blood at the point of injection or a previous bruising of the tissues, the animal will surely die of tetanus. It would seem, therefore, from these experiments, that a mixed infection is necessary to the development of tetanus when the infection is produced by spores. This fact is of the greatest importance in natural tetanus, for here the infection may be considered as being probably always produced by the bacilli in their spore stage, and the conditions favoring a mixed infection are generally present.

Tetanus bacilli and their spores have been found widely distributed in garden earth, hay dust, floors of dwellings and hospitals, on splinters of wood, old nails, in the air, etc. They have apparently been observed more frequently in certain localities than in others, as in some parts of Long Island and New Jersey, but they are probably equally distributed everywhere. This bacillus is the chief etiological factor in the production, not only of trismus and traumatic tetanus, but also of all the various forms of tetanus—puerperal tetanus, tetanus neonatorum, and idiopathic and rheumatic tetanus.

Tetanus Antitoxin.—Behring and Kitasato were the first to show the possibility of immunizing animals against tetanus. Here the question of immunity against infec-

tion does not consist in producing an increased power of resistance against the development of the infecting agent, but, similar to diphtheria, in bringing about an immunity to the effects of the tetanus toxin. The methods originally proposed by Behring and by Roux for producing a serum for the treatment of the disease consisted chiefly in weakening the tetanus toxin by means of chemical disinfectants (iodine trichloride, Gram's solution, etc.), so that when inoculated into the test animals they produced comparatively little reaction. At the present time pure unaltered toxin is injected either alone in small doses or along with antitoxin. After the first dose of toxin the animals acquire a certain tolerance which enables them to stand a dose of a less attenuated toxin or of a greater amount of unchanged toxin. Then by gradually increasing the doses or the strength of the toxin administered, the animals are finally able to bear injections of large quantities of the strongest toxin.

These immunizing experiments in tetanus have borne practical fruit, for it was through them that the principle of serum therapeutics first became known. It was thus shown that animals could be protected from tetanus infection by the previous or simultaneous injection of tetanus antitoxin, provided that such antitoxin was obtained from a thoroughly immunized animal; and from this it was assumed that the same result could be produced in natural tetanus in man. But unfortunately, the conditions in the natural disease are very much less favorable, inasmuch as treatment is usually commenced, not shortly after the infection has taken place, but often only on the appearance of tetanic symptoms, when the poison has already diffused itself through the body.

The tetanus antitoxin is prepared in the same manner as the diphtheria antitoxin—by inoculating the tetanus toxin in increasing doses into horses. The toxin is produced in bouillon cultures grown anaërobically. After ten or fifteen days the culture fluid is filtered through porcelain, and the germ-free filtrate is used for the inoculations. The horses receive 0.5 c.c. as the initial dose of a toxin of which 1 c.c. kills 250,000 gm. of guinea-pig, and along with this a sufficient amount of antitoxin to neutralize it. In five days this dose is doubled, and then every five to seven days, as rapidly as the horses can stand it, until they support 700–800 c.c. or more at a single dose. After some months of this treatment the blood of the horse contains the antitoxin in sufficient amount for therapeutic use. When the temperatures of the horses are normal and they have recovered from the dose of toxin last given, they are bled into sterile flasks and the serum collected.

Tetanus antitoxin is tested exactly as is diphtheria antitoxin, except that the standard unit is different. The test toxin used in the German method is one of which 1 gm. destroys 150,000,000 gm. of mouse. This is dissolved in 33⅓ c.c. of ten-per-cent. sodium chloride solution. Ten times the amount of antitoxic serum which neutralizes 1 c.c. of this dilution of the test toxin contains 1 unit of tetanus antitoxin. In the French method the amount of antitoxin which is required to protect a mouse from a dose of toxin sufficient to kill in four days is determined, and the strength of the antitoxin is stated by finding the amount of serum required to protect 1 gm. of animal. If 0.001 c.c. protected a 10 gm. mouse, the strength of that serum would be 1 to 10,000. Guinea-pigs are sometimes used instead of mice.

The dose of tetanus antitoxin for immunization is 10 c.c. of a serum of a strength of 1 to 1,000,000,000 unless the danger seem great, when the injection may be repeated after seven or eight days. For treatment it is well to begin with 50 c.c. and then, according to the severity of the case, give from 20 to 50 c.c. each day until the symptoms abate. The curative treatment in man has not been followed by very satisfactory results, owing to the fact already stated that the disease is generally too far advanced before treatment is commenced. From statistics collected by Lambert and others, however, of cases of tetanus treated with antitoxin, the remedy would seem to have been of undoubted practical use—so much so, at least, that in all cases in which tetanus is suspected or in which dirt has been ground into serious contusions, in gunshot wounds, etc., preventive inoculations of the serum should be given. In certain parts of France where tetanus is very prevalent among horses, Nocard distributed tetanus antitoxin to sixty-three veterinary surgeons, who treated with it, for the prevention of the disease, 2,727 of these animals. Only one of this number became affected, and this horse was not inoculated until five days after being pricked in shoeing. Although the delay was too great to prevent the appearance of tetanus, yet the disease was of a very mild nature. During the same period 259 cases in animals that were not so treated were observed. These striking results would certainly seem to indicate that the remedy deserves a much more extensive consideration in the treatment of patients with immunizing doses of serum than has heretofore been given it—at least in neighborhoods where tetanus is not uncommon (fortunately it is a rare disease in man), and when the dirty condition of their wounds leads one to suspect the possibility of tetanus infection. The recently proposed method of injecting from 3 to 15 c.c. of tetanus antitoxin into the lateral ventricles has not so far shown itself to be superior to the intravenous or subcutaneous methods, and is not in general to be recommended. No bad results have followed the injection of the antitoxin when the serum was sterile and the operation was performed aseptically.

THE BACILLUS OF TYPHOID FEVER (*Bacillus Typhi Abdominalis*).—This organism was first observed by Eberth, and independently by Koch, in 1880, in the internal organs of typhoid cadavera. It was obtained in pure culture by Gaffky in 1884; and has also been found during life in the blood, urine, and fæces of typhoid patients. Its etiological relationship to typhoid fever has been somewhat difficult of demonstration from the fact that, although pathogenic for many animals when artificially inoculated, it has not been easy to produce infection or give rise to lesions corresponding to those occurring in man. Still the results which have been obtained under certain conditions, together with the specific reactions of the blood serum of typhoid patients, and the constant presence of the bacillus in the spleen, blood, and excretions of the sick during life, have finally established, on a scientific basis, that this organism is the chief cause of typhoid fever.

Microscopical Appearances.—As met with in the organs of man and animals the typhoid bacilli are short, plump rods with rounded ends. They vary in size, being from 1 to 3 μ long and 0.5 to 0.8 μ broad, usually occurring singly, but sometimes growing into long threads, especially in certain culture media, as in potato. They are generally longer and somewhat more slender than the bacillus coli under similar conditions. (See Plate X., Fig. 7.)

Motility.—Actively motile, especially the short bacilli, each rod possessing from eight to fourteen flagella attached to the sides and extremities of the cells. The longer threads have a sinuous and more sluggish motion. (See Plate X., Fig. 8.)

Spore Formation.—Does not form spores. In stained preparations, particularly when grown on potato, refractive granules may be seen at the ends of the rods, which stain more intensely, and in the body of the cells "vacuoles" which remain unstained. These so-called Gaffky's spores, however, are not true spores, as the bacilli containing them show even less resisting power than the homogeneous bacilli found in other cultures, but are probably involution forms.

Staining Reactions.—The typhoid bacilli stain with the ordinary aniline colors, but a little less readily than do most other organisms, though this is not constant. They are decolorized by Gram's solution.

Biological Characters.—The bacillus typhosus grows most luxuriantly in the presence of oxygen, but oxygen is not essential to its development (facultative anaërobic). it grows fairly well also in an atmosphere of CO_2. Its growth on the ordinary culture media is similar to that of the bacillus coli communis, but somewhat slower and

not quite so abundant; in contradistinction to most other pathogenic micro-organisms, it grows well on slightly acid media. Below 10° C. it does not develop, its optimum temperature being at 37° C.; over 40° and below 30° C. its growth is retarded.

Growth in Gelatin.—In *gelatin plates* the deep colonies are not characteristic; they are small, punctiform, and sharply circumscribed, of a yellowish-brown color and finely granular in structure. The superficial colonies, however, particularly when young, are quite characteristic; they form a bluish-white, transparent, iridescent coating on the medium, with irregular outline, denser in the centre than at the periphery, and exhibiting under a low power a brownish color and wrinkled appearance. The gelatin is not liquefied.

In *gelatin stab cultures* the growth is mostly confined to the surface; it is thin, thready, often slightly granular, extending along the track of the needle and gradually reaching out to the sides of the tube; white to yellowish brown in color, irridescent and transparent. There is no liquefaction.

Growth in Agar and Blood Serum.—Not distinctive.

Growth in Bouillon.—This medium is uniformly clouded, but the clouding is not so dense as by the colon bacillus. After eighteen to twenty-four hours' growth a sediment is frequently developed, and a film forms on the surface, with a slightly acid reaction.

Growth in Potato.—The growth in this medium is generally considered to be very characteristic, but it varies considerably. The typical growth is a slightly moist, almost invisible, but luxuriant layer, usually covering the surface of the potato, and when scraped with the needle is tough and tenacious. Sometimes, however, the development is restricted, not very luxuriant, and of the same color as the medium. Again, it may be quite heavy, of a yellowish-brown color with a greenish halo, and similar to that of the colon bacillus. These variations in growth are thought to be due to the reaction (alkalinity) of the potato.

Milk is not coagulated, but some acid is produced by the typhoid bacillus. The bacillus coli communis, on the contrary, causes coagulation of milk in twenty-four to forty-eight hours at 37° C.

Vitality.—The typhoid bacilli withstand desiccation for months; according to Uffelmann in dried earth, clothes, etc., for two months or more. In dust, however, they do not seem to live so long. They resist cold remarkably well; freezing and thawing repeatedly under favorable conditions finally kills them. They are destroyed by heating to 60° C. in ten minutes and at higher temperatures still more rapidly. In fæces the bacilli retain their vitality for weeks or months, depending upon the number of putrefactive organisms present. In oysters they have remained alive for a month. In water which has been sterilized they live for many days; in ordinary water they are destroyed, by the concurrence of other bacteria, in about fourteen days; in running water this destruction takes place more rapidly. It thus appears that, under favorable circumstances, protected from light and other deleterious influences, the typhoid bacilli may retain their vitality outside of the body for a considerable length of time. But they may live also in the human body for a long time; Sahli has found them in the pleural exudate fifty days from the beginning of the disease, and Heintze observed them in a case of typhoid fever in periostitic pus ten months after convalescence.

Chemical Effects.—The typhoid bacillus produces no pigment or odorous substances. It reduces litmus solutions; converts nitrates into nitrites, the latter being gradually decomposed; forms lactic acid from grape sugar, but does not produce gas from carbohydrates; produces H_2S abundantly, but does not produce indol. The cultures are rich in toxins which, when freed from germs by filtration, are active disease producers.

Pathogenesis.—Although the typhoid bacillus is pathogenic for mice, guinea-pigs, rabbits, goats, etc., which when inoculated with virulent cultures die; showing symptoms of spasm, falling temperature, and diarrhœa, no experiments so far have produced in animals the typical lesions of typhoid fever in man. Certain experiments have indicated that the presence of other bacteria in the body, and of exposure to the action of poisonous gases in lowering the natural resistance of the individual, may render him more susceptible to typhoid infection. But whatever conclusions may be drawn from these results with regard to the typhoid process in animals, in the human subject typhoid fever is now generally recognized as a true infection, caused by the invasion and growth of typhoid bacilli in the body. This disease belongs to the class of infections known as *metastatic*—that is to say, diseases in which the specific infective organisms do not abound in the circulation, as in septicæmia, nor remain localized in one situation, but are distributed through the body in groups, the characteristic lesions of typhoid fever being in the lymphatic structures of the intestines, viz., the solitary follicles and patches of Peyer, the mesenteric glands, and the spleen; the liver and kidneys are less commonly affected.

Outside of the body the typhoid bacilli have been found so far only in comparatively few instances in water and soil, which have become contaminated with typhoid dejections; also recently in milk. They have never been found in healthy persons, except when convalescent from typhoid fever. In typhoid patients they have frequently been detected in the spleen and other organs (kidneys, liver, gall duct, etc.), the blood, urine, and fæces. They are most easily isolated from the spleen and lymphatic glands; they are often difficult to isolate from the excretions. The typhoid bacillus may give rise to the most varied complications along with the clinical symptoms of typical typhoid fever; it has been demonstrated to be the cause of suppurative inflammations of the spinal cord, of the brain and its membranes, of the lungs and kidneys, and of different suppurative processes, erysipelas, abscess, etc., in typhoid patients. The pyogenic functions of the typhoid bacillus are indeed no longer disputed. But at the same time in many cases of mixed infection in typhoid fever, the other pus cocci (streptococcus, staphylococcus, pneumococcus, etc.) are no doubt concerned in the production of the complications of the disease.

With regard to the *mode of infection* by the typhoid bacillus, there is no doubt that it is principally by way of the mouth and stomach to the intestines through drinking water, etc. In a case reported by Mayer in which death occurred on the second day of the disease, there were found on autopsy lesions of the lungs, spleen, kidneys, and intestines and great enlargements of the solitary follicles and patches of Peyer, but nowhere a trace of necrosis or loss of substance nor enlargements of the mesenteric glands. Microscopically an extraordinary deposit of characteristic typhoid bacilli was observed in the submucosa and interstitial spaces of the muscular tissue. In other cases, however, no intestinal lesions have been present, only a localization of bacilli and changes in the mesenteric glands and spleen revealing the nature of the infection. Here absorption probably took place more rapidly than usual, the bacilli not multiplying to any extent in the intestines. But not only do those cases which have been examined bacteriologically and pathologically, but also the epidemiological history of typhoid fever, prove beyond question that the chief mode of invasion of the specific bacillus is by way of the mouth. The infective material being discharged in the fæces and urine of typhoid-fever patients—in the latter of which especially the bacilli often persist for weeks or months—contaminate the water supply, articles of food, hands of nurses and attendants, etc., and thus spread infection from place to place. On this account the disinfection of the dejections of typhoid patients and convalescents cannot be too carefully looked after.

Immunization.—Specific immunization against experimental typhoid infection has been produced in animals by the usual method of injecting at first small quantities of the living or dead typhoid culture and gradually in-

creasing the dose. The blood serum of animals thus immunized has been found to acquire protective and curative bactericidal and possibly feeble antitoxic properties against the typhoid bacillus. These characters have also been observed in the blood serum of persons who have recovered from typhoid fever; and recently the attempt has been made to employ the typhoid serum of immunized animals or dead cultures for the cure and prevention of typhoid fever in man, but no marked results have been obtained.

Specific Reactions.—The following specific reactions have been utilized for the differential diagnosis of the typhoid bacillus from other similar organisms, and as an aid to the clinical diagnosis of obscure cases of typhoid fever:

1. The typhoid bacillus does not produce indol.
2. It does not produce fermentation or gas from media containing grape sugar, milk, or cane sugar.
3. On lactose litmus agar it grows usually as pale blue colonies, but occasionally causes slight redness of the surrounding medium.
4. *Widal's Serum Reaction.*—This reaction is based upon the fact, first observed by Pfeiffer, Gruber, and Durham, but since practically applied on a more extended scale by Widal, that living and actively motile typhoid bacilli if placed in the diluted blood or serum of a patient suffering from typhoid fever, within a very short time lose their motility and become aggregated into clumps. Either dried blood or serum may be used for the demonstration of the reaction. The blood is obtained by pricking with a needle the skin (previously disinfected) covering the tip of the finger or ear, and allowing two drops to fall on a glass slide, one near either end, where they dry. Fluid blood serum may be obtained in two ways: First, the tip of the finger or ear is pricked and the blood as it issues is allowed to fill by gravity a capillary tube having a central bulb, the ends of the tube being then sealed by heat and the serum allowed to separate from the clot. Second, a small piece of cantharides plaster is applied to the skin at some spot on the chest or abdomen, and from the blister thus formed in six to eighteen hours, the serum is collected in a capillary tube, the ends of which are then sealed. The latter method is the best, for the serum obtained is clear, free from blood cells and fibrin, which somewhat obscure the field on examination in the hanging drop, and is admirably suited to the test. Dried blood, however, obtained as above described answers all practical purposes of diagnosis.

The method of performing the serum test is as follows: A dilution of the blood or serum is first made in the proportion of one to ten. In the case of dried blood, it is dissolved in a little water and then mixed with the typhoid culture (eighteen to twenty-four hours old), the degree of dilution being guessed by the color. By previously making test solutions of dried blood in water of known proportions and noting the color the dilution may be approximately gauged. If serum is used which is preferable, not only because there is less fibrinous deposit but also because it is possible to make the dilution more accurately, one part of serum is added to nine parts of the broth culture. This should contain living and actively motile isolated bacilli. If there is no reaction when the mixture is observed in the hanging drop—that is to say, if within five minutes no marked change is noted in the motility of the bacilli and no considerable clumping occurs—the result may be regarded as negative, and no further test of the specimen is necessary. If complete clumping and immobilization of the bacilli occur within five minutes, this is a marked immediate typhoid reaction, and though this test is ordinarily sufficient for a positive diagnosis, the reaction may be confirmed with higher dilutions up to one to twenty, or more, if desired. If, however, upon examination of the mixture there is no marked reaction, but the bacilli only show in the first few minutes an inhibition in their motility and a tendency to clump, not complete within five minutes, it becomes necessary to test this with dilutions up to one to twenty, in order to measure the strength of the reaction. If in the one-to-twenty dilution a complete, distinct reaction takes place within thirty minutes, the result may also be considered positive, that is, that the blood or serum has come from a case of typhoid infection, while if a less marked reaction occurs it should be regarded as only probably typhoid, and another specimen should be requested. The time allowed by many observers for the development of the reaction with the higher dilutions is from one to two hours, but thirty minutes, in our opinion, is a safer and sufficient time limit. Positive results obtained in this way may be accepted as conclusive evidence of the recent or previous existence of typhoid infection in the patient. A former attack of typhoid fever within a period of several months or one or more years exceptionally vitiates the value of the reaction. On the other hand, the absence of reaction in any one examination does not exclude typhoid; so that, if the case remains clinically doubtful, repeated examinations should be made. The Widal reaction, though not infallible, when performed with due regard to the avoidance of every possible source of error, is as reliable as any other bacteriological test at present in use, and is of inestimable value as an aid to the clinical diagnosis of irregular or mild cases of typhoid infection. It is simple and easy of performance by any one versed in bacteriological technique. The serum reaction is never present in other diseases or in healthy persons, if correctly made and in the proper dilution, as is so often the case with Ehrlich's diazo reaction. It is better adapted for general employment than are any of the cultural methods now in use for isolating the bacillus from the fæces or urine. It is certainly safer than spleen puncture, and it is not so difficult as, though far more reliable than, the leucocyte count. The reaction does not appear, as a rule, during the first few days of the disease, but it is usually manifest before the rose-colored eruption appears, though occasionally it is very late in appearance (that is, not till the fourth or fifth week and sometimes only during a relapse), and in rare cases may be entirely absent. Although a negative result, therefore, has but little significance, a positive reaction when present—previous typhoid being excluded—is almost as strong evidence of the existence of the specific infection as the actual demonstration of the typhoid bacilli.

THE COLON BACILLUS (*Bacillus Coli Communis*).—This organism was first described by Emmerich (1885), who obtained it from the blood, organs, and intestinal discharges of cholera patients at Naples under the name *Bacillus Neapolitanus*. It has since been found to be a normal inhabitant of the intestinal canal of man and many animals. A number of similar bacterial species are now often spoken of as the *colon group* of organisms.

Microscopical Appearances.—The size and shape of the colon bacillus vary considerably according to the culture media (age, composition, etc.) from which it is derived. The typical form is that of short rods with rounded ends (0.4 to 0.7 μ in diameter and 1 to 3 μ in length); but sometimes the rods are so short as to be almost spherical, and again oval or thread-like forms may occur. The bacilli are found singly, joined together in pairs, rarely associated in short chains. In unfavorable culture media in stained preparations polar granules and vacuoles are frequently present, supposed to be due to degenerative changes in the protoplasm. (See Plate XI., Fig. 1.)

Motility.—The rods possess numerous long flagella, but usually very sluggish movements.

Spore Formation.—Absent.

Staining Reactions.—Stains readily with the ordinary aniline colors; is quickly decolorized by Gram's solution.

Biological Characters.—This organism grows best in the presence of oxygen, but also, though less luxuriantly, without oxygen and in an atmosphere of CO_2 (facultative anaërobic). It develops rapidly on almost all culture media (best in media containing sugar) even at room temperature; optimum temperature 37° C. It grows fairly well in slightly acid media, but itself produces so much acid that it is sometimes destroyed in this way. It is almost impossible to distinguish culturally the bacillus

coli from the bacillus typhi, except that the growth of the former is somewhat more abundant under similar conditions.

Growth in Gelatin.—In *gelatin plates* colonies are developed in from twenty-four to forty-eight hours, which resemble greatly the colonies of the typhoid bacillus, except that they are larger for the same period of growth. The deep colonies are round, oval or "whetstone" shaped, finely granular, almost homogeneous in structure, and of a pale yellowish to brownish color, at first; later they become denser, darker, and more coarsely granular. The surface colonies appear as small, dry, irregular, flat, iridescent points with wavy bent borders. In *stab cultures* the growth usually takes the form of a nail with flattened head, the surface extension soon reaching out to the sides of the tube. The gelatin is not liquefied.

On agar and blood serum an abundant, soft, grayish-white layer is quickly developed in the incubator, but the growth is not characteristic.

In *bouillon* the colon bacillus produces diffuse clouding with sedimentation; a pellicle is sometimes formed on the surface; a decided fecal odor is often noticed in old cultures.

Milk is usually coagulated with the production of gas and acid.

On *potato* the growth is rapid and abundant, appearing after twenty-four to thirty-six hours in the incubator as a yellowish-brown to dark cream-colored deposit on the surface. The growth may, however, be scanty or absent at times.

Chemical Effects.—This bacillus forms pigment only on potato. Ill-smelling substances are developed on agar, gelatin, occasionally in old bouillon cultures, but particularly on potato media. The bacillus coli grows rapidly in media containing carbohydrates (grape and milk sugar, etc.), causing active fermentation with liberation of gas (CO_2 and H). Cultivated in solid media, to which glucose has been added, the gas production is recognized by the appearance of numerous bubbles; in fluid culture media it may be demonstrated in the fermentation tube. Grown on lactose-litmus agar, the colonies are pink and the surrounding medium is changed from blue to red, showing the production of acid. The colon bacillus produces in bouillon and peptone solutions H_2S and indol. It converts nitrates into nitrites. Urea is decomposed by many species of this group.

Vitality.—Similar to that of the typhoid bacillus, but is more resistant to the action of acids, formalin, and other chemical disinfectants. Thermal death point 60° C. in ten minutes' exposure.

Pathogenesis.—The colon bacillus is pathogenic for mice, guinea-pigs, and rabbits in varying degrees according to the strength of the virus and mode of inoculation; the results of animal inoculations, however, as with the typhoid bacillus, cannot always be predicted with certainty. The more rapidly death ensues the greater is the number of bacilli found in the body; they are always more abundant in the abdominal cavity than in the blood,—in other words, the result is due to the toxic rather than to the infective properties of the culture used. The lesions produced are those of enteritis; the duodenum and jejunum are found to contain fluid, the spleen is somewhat enlarged, and there is marked hyperæmia and ecchymosis of the small intestines, together with swelling of Peyer's patches.

Immunization against colon infection is easily produced in the usual way by the inoculation of gradually increasing doses of cultures of living or dead bacilli.

The bacillus coli communis is a common inhabitant of the intestines of man and animals, being found in the fæces, milk, bile, etc. Of thirty-two cadavera of healthy individuals examined twenty-four to thirty-six hours after death it was found in sixteen, especially in the liver and kidneys. It is also frequently met with in river water and food, so that it is one of the most widespread saprophytic bacteria. Formerly it was thought that the presence of the bacillus coli in water was sufficient proof of its contamination by fæces, and thus of its possible contamination also by typhoid bacilli. But recent investigations have shown that there are no grounds for this assumption, as the colon bacillus may reach the water from many different sources. At the same time, in a general way, drinking water found to contain colon bacilli may be regarded as unfit for human consumption.

This organism is associated with many diseases especially of the abdominal organs, though it is not positively known what etiological relation, if any, it bears to these affections. It has been found in peritonitis, appendicitis, cystitis (partly alone, particularly when the urine is acid, and partly together with the proteus vulgaris and other bacteria), urethritis, pyelonephritis, etc. The colon bacillus has been assumed to be the cause of *cholera nostras* and *cholera infantum*, but the investigations of Booker, Baginsky, Escherich, and Flügge would seem to indicate that these diseases are of a much more complicated origin, being due probably to certain ferments and toxins in the intestines produced, not by any specific micro-organisms, but by the ordinary putrefactive bacteria, among which the B. coli and B. proteus vulgaris are the most commonly present. The cause of infections of the gall ducts and multiple abscesses of the liver is also explained in this way. Puerperal fever is not infrequently due, in part at least, to infection of the vagina or uterus by the colon bacillus. Other diseases to which this organism seems to stand occasionally in relation are endocarditis, meningitis, tropical abscess of the liver, bronchopneumonia, fetid bronchitis, amygdalitis, etc. In these diseases the bacillus coli communis has been found sometimes alone, but usually associated with other pathogenic bacteria in such numbers that it must be considered a factor in the etiology of the affections, and in some cases there is reason for belief that it may be the primary cause. Though further study is required to show the specific pathogenic properties of this micro-organism, it is evident that under certain conditions it may become pathogenic to man.

Differential diagnosis between the B. coli and B. typhi abdominalis: The following characteristics and tests constitute the chief means of differentiating these two similar micro-organisms, though none of them alone can be depended on:

1. The motility of the colon bacillus is, as a rule, not very pronounced, sometimes absent; that of the typhoid bacillus is usually very active.

2. On gelatin plates the colon bacillus develops more rapidly and luxuriantly than the typhoid bacillus, and on potato it grows more abundantly, being almost always visible.

3. The colon bacillus coagulates milk with acid reaction within twenty-four to forty-eight hours; the typhoid bacillus does not coagulate milk.

4. The colon bacillus causes fermentation with production of gas in media containing sugar; the typhoid bacillus does not.

5. In nutrient agar or gelatin containing lactose and litmus tincture and of a slightly alkaline reaction, the color of the colonies of colon bacillus is pink and the surrounding medium red; while the colonies of typhoid bacillus are blue and there is little or no reddening of the medium.

6. The colon bacillus produces indol in cultures of bouillon or peptone; the typhoid bacillus does not.

7. When a twenty-four-hour-old bouillon culture of the colon bacillus is mixed with the blood or serum of a patient suffering from genuine typhoid fever, in a dilution of one to ten or more, after the first week of the disease, the Widal reaction is negative; cultures of the typhoid bacillus treated in the same manner and examined in the hanging drop give the characteristic agglutination and clumping of the bacilli.

8. Finally, we have the special media, devised respectively by Hiss, Capaldi, and Elsner, for isolating the colon and typhoid bacilli, in which we may observe their differences of growth in plate and tube cultures. These will be referred to more in detail elsewhere.

FRIEDLÄNDER'S BACILLUS OF PNEUMONIA (*Pneumobacillus*).—This organism was discovered by Friedländer (1883) and declared to be the cause of fibrinous pneumonia. Subsequently it was shown that it is seldom found in pneumonia patients, being often present in the mucous membranes of the mouth and air passages of healthy persons and in the air.

Microscopical Appearances.—Short rods (0.6 to 3 μ long by 0.5 to 0.8 μ broad) with rounded ends, often resembling micrococci, especially in recent cultures; commonly in pairs or chains of four. A capsule is present in specimens from sputum and inoculated animals; rarely seen in cultures.

Motility.—Absent.

Spore Formation.—Does not form spores.

Staining Reactions.—Stains readily with the ordinary aniline dyes, but not by Gram's method.

Biological Characters.—Grows luxuriantly both in the presence and absence of oxygen (facultative anaërobic) and on all the usual culture media, at the room temperature and in the incubator.

In *gelatin plates* small, round, elevated white colonies develop, slightly granular in structure and of a brownish color. In *gelatin stab cultures* a typical nail-shaped growth occurs; the gelatin is not liquefied. On *agar and blood serum* large grayish-white, moist colonies develop. The growth on *potato* is abundant,—a thick, yellowish-white, glistening coating containing gas bubbles. *Bouillon* is clouded. *Milk* is not coagulated. Media containing glucose are decomposed, undergoing *fermentation* with the production of acid. Indol and H_2S are sparingly produced.

Pathogenesis.—This bacillus is pathogenic for mice and guinea-pigs, less so for dogs, and rabbits are apparently immune (thus distinguished from Fraenkel's *diplococcus pneumoniæ*). Susceptible animals are inoculated directly into the pleural and abdominal cavities. They can also be affected by inhalation of dried pulverized cultures. In some cases pneumonic lesions are produced.

Active *immunity* against Friedländer's bacillus is readily produced, and although the organism is non-motile the agglutinating serum reaction is said to be present.

This bacillus has been found outside the body in the dust of floors, in the air, etc. It has been met also in the saliva of healthy persons. It is the cause of only a small proportion of the cases of lobar pneumonia; in one hundred and twenty-nine cases examined by Weichselbaum the pneumobacillus was found in nine. According to Netter and Weichselbaum the cases due primarily to this organism are distinguished by their peculiarly malignant type and by the viscidity of the exudate produced. It is also probably concerned, primarily or secondarily, under certain circumstances, in the production of pleurisy, abscess of the lungs, pericarditis, endocarditis, otitis media, and meningitis, in all of which diseases it has been found at times. It has been met with in all the organs of the body and also in the blood.

THE PUS-PRODUCING ORGANISMS.

Many bacteria are capable of producing, under certain conditions, inflammatory and suppurative processes, abscess, cellulitis, septicæmia, etc. The micro-organisms most commonly found associated with suppuration are staphylococci, streptococci, pneumococci, and tetracocci. The following species are also occasionally met with: the colon bacillus and allied members of that group, the typhoid bacillus, the influenza bacillus, and the bacillus pyocyaneus. In so-called "cold abscesses" the tubercle bacillus is usually the only organism present. Besides these bacteria, other species may sometimes cause circumscribed suppurative processes.

STAPHYLOCOCCUS PYOGENES AUREUS.—This is one of the commonest pathogenic bacteria, being present almost everywhere. It is the most frequent cause of acute circumscribed suppurative inflammations. Though first observed by Ogston (1881) in the pus of acute abscesses, it was not obtained by him in pure culture but was isolated and accurately described by Rosenbach in 1884.

Microscopical Appearances.—Small, spherical cells, having a diameter of about 0.8 μ, occurring singly or in pairs, but usually arranged in irregular masses simulating clusters of grapes; hence the name, from σταφυλὴ, "grape." (See Plate XI., Fig. 3.)

Motility.—Non-motile.

Staining Reactions.—Stains easily in aqueous solutions of the basic aniline dyes; is not decolorized by Gram.

Biological Characters.—Aërobic and facultative anaërobic, but produces pigment only in the presence of oxygen. It grows readily at a temperature of from 18° to 20° C., but best at 39° C., on all the ordinary culture media.

Growth on Gelatin.—Grown on *gelatin plates* at room temperature, it develops within forty-eight hours punctiform colonies, which, when examined under a low-power lens, appear as circular discs of a pale or yellowish brown color, somewhat darker at the centre and surrounded by a transparent zone with well-defined border. Immediately around the colonies, which grow rapidly and are slightly granular in structure, there is a deepening of the surface of the gelatin, due to its liquefaction. Later, the liquefaction becomes general, the colonies running together. In *gelatin stab cultures* a white confluent deposit first develops along the line of puncture, followed by liquefying of the medium in the form of a stocking. At the end of two days the yellow pigment begins to form, and this increases in intensity until finally (after a week) complete liquefaction takes place and the "golden staphylococci" fall as an orange-colored deposit to the bottom of the tube. Under unfavorable conditions the staphylococcus aureus gradually loses its property of liquefying gelatin and producing pigment.

Growth in Agar.—In *streak* and *stab cultures* on nutrient agar a whitish growth is at first produced, and this after a few days also becomes golden yellow on the surface. Colonies found at the bottom of a stab culture or under a layer of oil remain white; showing the inability of this organism to produce pigment in the absence of oxygen.

Bouillon is densely clouded by the luxuriant growth.

Milk is coagulated in from one to eight days with the production of acid.

Chemical Effects.—The production of an orange-yellow pigment, but only in the presence of oxygen; agar cultures smell like glue or spoiled paste; gas and acid production from carbohydrates; the production of H_2S abundantly and a little indol; the decomposition of urea by certain species,—these are the chemical effects of the staphylococcus.

Vitality.—Several cases of osteomyelitis have been reported in which staphylococci have been found alive in the body in the centres of infection after many years, during this time having been encapsulated apparently. In cultures they retain their vitality for a year or more. The staphylococcus is distinguished from most other pathogenic bacteria by its greater power of resistance to all outside influences, desiccation, heat, chemical agents, etc. It does not, however, form spores, as far as we know. In dried pus, according to Hägler, it stands desiccation for from fifty-six to one hundred days. But it is rapidly killed by moist heat at 70° C. It retains its vitality in ice sixty-six days (Prudden). Disinfectants act on it slowly. Meade Bolton found that a one-per-cent. carbolic acid solution destroyed it in two hours; mercuric chloride 1 to 1,000 killed it in five to ten minutes. But there is a considerable difference in the resisting power of the micrococci.

Pathogenesis.—The pathogenic effect of the staphylococcus pyogenes aureus on test animals varies much according to the mode of application and the virulence of the culture employed. Experiments have shown that this organism as found in suppurative processes in the human subject is not as infectious for animals as it is for man. The order of susceptibility seems to be as follows: man, horses, dogs, cattle, goats, sheep, rabbits, guinea-pigs,

mice. In man a simple rubbing of the unbroken skin with pus from an acute abscess is usually sufficient to produce purulent inflammation. Cutaneous inoculation of animals is negative, but subcutaneous injection causes a local abscess in rabbits, guinea-pigs, and mice, and intravenous injection in rabbits sometimes produces pyæmia and after injury to the cardiac valves ulcerative endocarditis.

The filtrates from bouillon cultures contain highly virulent toxic substances. Injection of these into the peritoneal cavity of dogs causes sero-sanguineous peritonitis, and ecchymoses in the serous and mucous membranes of the intestines, finally resulting in death with bloody diarrhœa. *Immunity* against staphylococcus infection may be produced by the injection of gradually increasing doses of the pure culture either living or previously sterilized by boiling. The blood serum of animals which have been thus immunized possesses slight protective and curative effects in other animals, but no practical use of this serum has been attempted in man.

The staphylococcus aureus occurs outside the body in milk, water, soil, air, etc. Ten per cent. of the micro-organisms present in the air of surgical clinics consist of staphylococci (Ullmann). It is found on the healthy skin, in the mouth, vagina, cervix uteri, and milk of nursing mothers. It is the chief cause of all acute inflammatory suppuration, in many cases the sole cause. It is commonly found, however, in association with streptococci, pneumococci, colon bacilli, typhoid bacilli, etc. The following affections particularly are frequently caused by the staphylococcus aureus and other species: acne, sycosis, impetigo, pemphigus, conjunctivitis, furuncle, abscess, periostitis, osteomyelitis, parotitis, tonsillitis, mammitis, ulcerative endocarditis, pyelonephritis, etc. It is the principal etiological factor in the production of pyæmia in the various pathological forms of that condition.

Not all persons, however, are equally susceptible to infection by the staphylococcus; those who are in a cachectic condition or suffering from constitutional diseases, like diabetes, are especially liable to infection. In healthy individuals certain parts of the body, as the back of the neck, and seat, seems to be more subject than others to attack by furuncles, carbuncles, and the like. In persons in whom sores are readily produced in consequence of disturbances of nutrition, the micrococci find a suitable resting place at the points of least resistance, as in the bones of weakly children, in fractures, and injuries in general.

Staphylococcus pyogenes albus is morphologically identical with staphylococcus pyogenes aureus, and is probably a variety of the same organism which has lost its power of producing pigment. On the average it seems to be somewhat less pathogenic.

Staphylococcus pyogenes citreus is also probably identical with the above-mentioned species, except that it forms by its growth a lemon-yellow pigment. It is found in about ten per cent. of cases in the pus of acute abscesses, usually in association with other pyogenic cocci.

Staphylococcus epidermidis albus is another variety no doubt of staphylococcus pyogenes albus, but found on the surface of the body and often in parts of the epidermis deeper than can be reached by any known means of cutaneous disinfection except by heat. According to Welch it is far less virulent than the staphylococcus pyogenes aureus. It is frequently present in aseptic wounds, but does not seem to interfere with their healing, although sometimes it may cause suppuration along the drainage tube, and is the common source of "stitch abscess."

Micrococcus Tetragenus (*Tetracoccus*).—This micrococcus was discovered by Koch in 1884 in a phthisical lung cavity. Gaffky made a further study of it and described its pathological properties for various test animals. Biondi found it in human saliva; here, however, it is sometimes simply an evidence of mouth contamination, not of lung infection. In pulmonary tuberculosis it is commonly associated with other pathogenic bacteria, which, though playing no part in the etiology of the primary affection, contribute no doubt to the progressive destruction of the lung tissue. Its pyogenic character is shown by its not infrequent presence in the pus of acute abscesses, empyema, etc.

Microscopical Appearances.—When obtained from the animal body it occurs mostly in groups of four surrounded by a capsule. In cultures the cocci are seen in various stages of division as large round, undivided cells, in pairs of oval elements, and in groups of three or four. When the division is complete they remind one of sarcina in appearance, except that they divide in four instead of in three directions and are not built up like cotton bales. (See Plate XI., Fig. 4.)

Motility.—Non-motile.

Staining Reactions.—Stains readily with the ordinary aniline dyes; is not decolorized by Gram.

Biological Characters.—Grows both in the presence and absence of oxygen, but best with oxygen, in the usual culture media. It may be cultivated at room temperature (20° C.); the optimum being between 35° and 38° C. The growth is slow under all conditions.

Growth in Gelatin.—On *gelatin plates* small, white to grayish-yellow, shiny, prominent, round, or lemon-shaped colonies develop. In *gelatin stab cultures* it grows equally as well on the surface as along the track of the needle; forming on the surface a thick, white, shiny mass, and filling out the fissures along the line of puncture. The gelatin is not liquefied.

On *agar and blood serum* the growth on the surface is moist and glistening. The colonies appear as small, transparent, round points of a grayish-yellow color and slightly elevated.

Pathogenesis.—Subcutaneous injections of a culture of this micrococcus in minute quantity are usually fatal to white mice in from three to six days. The organisms are found chiefly in the spleen, lungs, liver, and kidneys, few in the blood. Gray mice are generally immune. Rabbits and dogs are also little susceptible. In guinea-pigs only a local reaction or abscess sometimes follows inoculation, and again they die from septicæmia; intraperitoneal injections produce purulent peritonitis, groups of micrococci being found in the exudate.

Streptococcus Pyogenes (*Streptococcus Erysipelatis*).—This micro-organism was first observed by Koch in stained sections of tissues attacked by septic processes, and by Ogston in the pus of acute abscesses (1882). It was obtained in pure cultures by Fehleisen (1883) from a case of erysipelas, and its pathological properties proved. Rosenbach (1884) and Krause and Passet (1885) isolated it from pus and gave it the name of *streptococcus pyogenes*. It has since been shown to be the chief cause of many suppurative inflammations. Formerly the streptococci of erysipelas, acute abscess, septicæmia, puerperal fever, etc., were thought to belong to different species, because they possessed certain differences in their pathological effects and morphological peculiarities, according to the source from which they were derived. But now it is recognized that these slight differences are not sufficient to constitute separate species, but only varieties of the same species. At the same time, however, there would appear to be some streptococci, which, in so far as their specific reaction in the presence of a protective serum is concerned, are as distinct from the streptococcus pyogenes as is the pneumococcus. This question is of practical importance, for upon its solution depends our ability to select a suitable protective serum in different cases of streptococcus infection.

Microscopical Appearances.—Spherical micrococci from 0.4 to 1 μ in diameter, usually larger than the staphylococci, characteristically arranged in chains of eight, ten, twenty, or more elements, but also associated in pairs and sometimes in irregular masses. (See Plate XI., Fig. 2.)

Motility.—Non-motile.

Staining Reactions.—Stains easily with all the basic aniline dyes and by Gram's method.

Biological Characters.—Facultative anaërobic, growing

both in absence and presence of oxygen, and on the various liquid and solid culture media. The growth is slow, developing best at from 30° to 37° C., but also at room temperature (18° to 20° C.). There is no growth over 47° C.

Growth on Gelatin.—In *gelatin plates* small, white to yellowish or brownish granular round colonies develop, which do not liquefy the gelatin; though occasionally, with unusual varieties, a certain amount of liquefaction has been observed. Under a high power, chains of streptococci may be seen projecting from the sides of the discs. In *gelatin stab* cultures the growth is not confluent, but individual colonies are arranged beside one another along the line of puncture.

Growth on Agar.—On *agar plates* the colonies are visible after twelve to thirty hours' growth, and when magnified sufficiently show beautiful chain cocci often in the form of twisted loops. The colonies are circular in shape when thinly scattered over the plates, but irregular when crowded together.

Growth in Bouillon.—The growth in this medium is variable in different varieties; in slightly alkaline bouillon at 37° C. reaching their full development within thirty-six to forty-eight hours. Streptococci which grow in long chains usually give an abundant flocculent deposit and leave the liquid clear; the deposit may, however, be granular, in larger flakes or in tough masses; sometimes the broth is clouded. Those growing in short chains, as a rule, cause diffuse clouding of the bouillon, with a granular deposit at the bottom of the tube. The development in a mixture of ascitic fluid and bouillon, which is the best medium for the growth of the streptococcus, is more abundant than in plain bouillon.

Growth in Solidified Blood Serum.—This is also an excellent medium for the cultivation of the streptococcus. Tiny grayish colonies appear after twelve to eighteen hours. *Milk* is usually coagulated with the production of acid, but not always.

The growth on *potato* is scanty.

Vitality.—Cultures of the streptococcus die much sooner than those of the staphylococcus, very few living over a month and the majority dying within a few days; they live longest in serum bouillon or a mixture of ascitic fluid and bouillon, and may be kept thus for a considerable time in small sealed glass tubes in the ice chest. When dried in blood or pus, the streptococci retain their vitality for several months at room temperature, and still longer in the refrigerator. The thermal death point, according to Sternberg, is between 52° and 54° C., the time of exposure being ten minutes.

Chemical Effects.—As products of their growth the streptococci form but little pigment, no indol, a little H_2S, and as a rule no acids or gases from carbohydrates. From albuminous culture media they produce toxins which are precipitated by alcohol but are soluble in water. To obtain these toxins the cultures are killed by chloroform or filtered through porcelain. Introduced into animals in considerable quantities they cause suppuration and fever and even death; they seem to belong to the class of so-called toxalbumins.

Pathogenesis.—The majority of test animals are not very susceptible to infection by the streptococcus, and hence it is difficult to obtain any definite pathological changes in their tissues by inoculations of cultures. White mice and rabbits are the most susceptible, and these animals are, therefore, usually employed for experimentation. The virulence of streptococci, however, varies greatly for animals and is different from their virulence for the human subject. The most virulent cultures, when injected in small quantity into the circulation or the subcutaneous tissues of a mouse or rabbit, produce death by septicæmia. Less virulent varieties require the injection of large quantities to produce a similar result, while some produce only abscess or erysipelas when injected subcutaneously, and others have no effect at all when introduced directly into the circulation. Many of the streptococci obtained from cases of cellulitis, abscess, empyema, and even septicæmia belong to this group.

A number of varieties of streptococci have thus been discovered, differing in virulence and in their growth in culture media; but all attempts to separate them into classes until recently, through the use of specific serum, have failed, because the differences observed, though often marked, are not constant. Knorr has enunciated the following important facts with regard to the virulence of streptococci: All varieties when cultivated for any length of time on artificial media gradually lose their virulence. By continuous passage through certain susceptible animals, as mice, a streptococcus is obtained which is very pathogenic for those animals, but at the same time has lost its virulence for others, as rabbits. The more virulent is any variety of streptococcus for an animal, the more certainly it kills without suppuration, which is produced only by less virulent forms. There seems also to be a strong tendency for a streptococcus to produce the same kind of inflammation, when inoculated, as the one from which it was derived; for example, streptococci from erysipelas tend to produce erysipelas, from septicæmia to produce septicæmia, etc. Streptococci, however, obtained from different sources (abscesses, puerperal fever, sepsis, erysipelas, etc.) are sometimes capable of producing erysipelas when inoculated into the ear of a rabbit, provided they possess sufficient virulence. By continued passage of fatal doses through susceptible animals Marmorek has obtained cultures of streptococci of such virulence that 0.0001 c.c. subcutaneously injected into mice almost invariably killed them, while 0.000001 c.c. sometimes produced death—*i.e.*, in amounts which contained but a very few organisms. According to this investigator, the virulence may be retained by cultivation in mixtures consisting of two parts of serum and one part of bouillon, or one part of ascitic or pleuritic fluid and two parts of bouillon, such cultures being kept for two months or more without transplantation to fresh media.

Streptococci have been found outside the body in the soil, in water, and in the air of surgical clinics, etc. In healthy persons they have been observed in the mouth, nasal cavities, vagina, and infrequently in the cervix uteri, sometimes in virulent forms. The streptococcus pyogenes may give rise in man to a number of inflammatory and suppurative processes. It is frequently the primary cause of infection in erysipelas, acute abscesses, cellulitis, lymphangitis, tonsillitis, bronchitis, pneumonia, sepsis, puerperal fever, impetigo contagiosa; less commonly in pleuritis, pericarditis, meningitis, periostitis, osteomyelitis, otitis media, mastoiditis, empyema, etc. Associated with other bacteria in diseases of which they are the specific cause, the streptococcus has also been found contributing to secondary or mixed infection in pulmonary tuberculosis, broncho-pneumonia, scarlet fever and septic diphtheria, playing an important part in these affections in the production of septicæmia and fever. So uniformly present are streptococci in the pseudo-membranous inflammations of scarlatina that some authorities have claimed that a certain variety of streptococci (*streptococcus conglomeratus* of Kurth and Klein) is the specific cause of this disease. The streptococcus pyogenes is further the probable cause of a number of cases of nephritis, arthritis, and myelitis, being frequently found in the blood and urine, with or without symptoms of general intoxication.

In animals such as horses, asses, cows, sheep, goats, and dogs, the streptococcus also produces diseases similar to those observed in man. These organisms have not infrequently been found in the vaccine lymph of stations where this is prepared, though generally the non-virulent varieties.

Almost all of the diseases above mentioned have been produced experimentally in animals, the result depending upon the susceptibility of the animals employed, the virulence of the streptococci, and the amount of infective material injected. The causal relation of this organism to disease has also been demonstrated in man. Fehleisen has inoculated cultures obtained from the skin of patients suffering from erysipelas into persons with inoperable

malignant growths—lupus, carcinoma, and sarcoma—and has produced a typical erysipelatous inflammation in from fifteen to sixty hours. Persons who had recently recovered from an attack of erysipelas proved to be immune. In such persons also it was observed that malignant tumors apparently improved or entirely disappeared after inoculation. During the last few years this fact has been made use of in the treatment of cancers by the artificial production of erysipelas through inoculation of pure cultures or of their toxic products, and in some cases of spindle-celled sarcoma, according to Coley, with considerable success. In carcinomata the results have been very slight.

Susceptibility and Immunity.—As with the staphylococcus, the streptococcus is more liable to invade the tissues and produce inflammation and suppuration when the standard of health is reduced from any cause, and especially when by absorption or retention toxic products are present in excess in the body. Thus local streptococcus infections are more likely to occur as complications or sequelæ in various specific diseases, in chronic alcoholism, in constitutional affections in those exposed to septic emanations from sewers, etc., and in cases in which there is absorption of toxic products formed in the alimentary canal as the result of the ingestion of improper food, of constipation, etc.

Just as in persons who have recovered from an attack of erysipelas there has been observed a slight immunity to further infection, so it has been found that animals, after recovering from artificial inoculation of the toxic products of the streptococcus, acquire a moderate immunity, which may be increased by the administration of gradually increasing doses of the culture. In this way Knorr has immunized rabbits against an intensely virulent streptococcus by injections of slight virulent cultures; Pasquale has partially immunized these animals against septicæmia; and Marmorek has protected sheep, asses, and horses against very large doses of a streptococcus which though but slightly virulent for them was intensely so for rabbits.

In none of the streptococcus infections in man, however, is there apparently produced lasting immunizing substances in the blood after a single attack. In cases of erysipelas, cellulitis, and abscess, recovery after periods varying from a few days to several months would seem to indicate the presence of slight or transitory protective substances; but the severe forms of infection, such as septicæmia following operations and puerperal fever, show little tendency to recovery when once well established.

Marmorek was the first to attempt to produce a curative anti-streptococcus serum obtained from immunized animals (asses and horses) for the treatment of streptococcus infections. The results reported from the use of this serum since his first communication in 1895 have been very variable, and on the whole unsatisfactory. The protective power of anti-streptococcus serum is undoubtedly specific, but it soon loses this power and often is practically useless six weeks after its preparation. It has, moreover, been shown that the same serum does not confer immunity apparently to any other variety of streptococcus than the one which was originally employed in the immunizing inoculations, each variety of streptococcus producing a serum which is protective only against its own variety. In order to produce a serum, therefore, which should have a successful therapeutic effect, the animals must be immunized against every variety of pathogenic streptococci. This being the case it will be readily understood that the anti-streptococcus serum which has been heretofore employed in the majority of cases was probably valueless. The poor results so far obtained from the clinical use of this remedy may have been due either to the preparations having already lost their protective power, or to this power not being sufficient in the doses given to have any effect, or to the cases having been those of severe general septicæmia upon which the serum could have no action, or to the infection having been due to some variety of streptococcus different from that for which the animals were immunized, or to the cases not being those of streptococcus infection at all, but due to other organisms, as the staphylococcus, colon bacillus, pneumococcus, etc. It is evident, therefore, that the therapeutic use of anti-streptococcus serum is at present very problematical; at the same time, however, it does not follow that a preparation may not be obtianed which shall have practical value.

The following varieties of streptococci have been described by some authors:

Streptococcus Brevis.—Develops in bouillon slightly curved, short chains; the bouillon is clouded. Gelatin is liquefied immediately around the colonies. There is a distinctly visible growth on potato. Grows at 10° to 12° C. Is usually non-virulent.

Streptococcus Longus.—Develops in bouillon long twisted chains, with a granular or flocculent sediment, the supernatant liquid remaining clear. Gelatin is not liquefied. There is no visible growth on potato. No growth under 14° to 16° C. Is usually highly virulent.

The following subdivisions of the streptococcus longus have also been described: (1) *Streptococcus turbidus* with clouded bouillon culture; (2) *Streptococcus viscosus* with clear bouillon culture and slimy sediment; (3) *Streptococcus conglomeratus* with clear bouillon culture and granular sediment.

The Pneumococcus (*Micrococcus Lanceolatus; Diplococcus Pneumoniæ*).—This micrococcus was first observed by Sternberg, and almost simultaneously by Pasteur (1880), in the blood of rabbits inoculated from human saliva. It was subsequently described by Talamon (1883) and demonstrated by him to be capable of producing fibrinous pneumonia in rabbits when introduced directly into the lung of these animals. In 1885–1886 this micro-organism was subjected to an extended series of investigations by Fraenkel, Weichselbaum, Sternberg, and others, and proved to be the chief cause of lobar or croupous pneumonia in man.

Microscopical Appearances.—Very irregular; occurs as spherical or oval and lancet-shaped cocci usually united in pairs (diplococci), but sometimes as short chains consisting of four to six elements and resembling streptococci. In stained specimens from sputum, the fibrinous exudates of croupous pneumonia, the blood of inoculated animals and cultures on blood serum, the lancet-shaped cells are commonly surrounded by a gelatinous capsule. Variation in form and arrangement is characteristic of the pneumococcus, there being great differences according to the source from which it is obtained. (See Plate XI., Figs. 5 and 6.)

Motility.—Non-motile.

Staining Reactions.—Stains readily with ordinary aniline dyes; is not decolorized by Gram's solution. The capsule may be demonstrated in cover-glass preparations either by Gram's or Welch's (glacial acetic acid) method.

Biological Characters.—Aërobic and facultative anaërobic, grows equally well in the presence and absence of oxygen. It develops on almost all culture media having a slightly alkaline reaction; but the growth is slow and scanty, and the virulence and power of reproduction are soon lost. Grows very slowly, often not at all at room temperature; optimum 37° C., maximum 42° C.

Growth on Gelatin.—The growth on this medium is slow, often none at all, owing to the low temperature (22° to 25° C.) at which gelatin has to be kept. The gelatin is not liquefied.

Growth on Agar and Blood Serum.—At the end of forty-eight hours in the incubator, there appears on agar a thin colorless layer of non-confluent colonies. If blood serum or ascitic fluid be added to the agar the colonies are larger and closer together, the growth being more luxuriant. The growth of Loeffler's blood-serum mixture is very similar to that on agar, but is somewhat more vigorous, appearing on the surface as small, fairly granular dew-drop-like colonies.

Growth in Bouillon.—At the end of twelve to twenty-four hours in the incubator a slight clouding is produced, due to the development of the organisms, which on micro-

scopical examination are seen to consist of pairs or longer and shorter chains. After two or three days the medium again becomes transparent, the cocci sinking to the bottom of the tube. The best fluid medium for the cultivation of the pneumococcus is a mixture composed of bouillon two parts and ascitic or pleuritic fluid one part. In this medium the organisms grow well, and cultures kept in a cool place and prevented from drying retain their vitality for a number of months.

Milk is a favorable medium, and in some cases coagulation takes place.

Vitality.—In cultures the pneumococcus soon loses its vitality; it lives longest in media containing blood or serum. Pneumonic sputum attached to cloths, air-dried and exposed to diffuse daylight, retained its virulence for rabbits for periods of nineteen and fifty-five days in different experiments. Exposed to direct sunlight the same material retained its virulence after twelve hours' exposure (Bordoni-Uffreduzzi). This resistance of the organism for so long a time under these conditions is attributed in part to the protective influence afforded by the albuminous envelope surrounding the micrococci in the sputum.

Chemical Effects.—Three varieties of pneumococci have been isolated which produce a brick-red pigment. Filtered and dead unfiltered cultures contain toxins as products of growth. For other chemical effects, see Streptococcus.

Pathogenesis.—The pneumococcus is quite pathogenic for some animals, especially mice and rabbits; rats are less susceptible, and guinea-pigs, sheep, dogs, and birds are almost immune. In mice and rabbits the subcutaneous injection of small quantities of pneumonic sputum in the early stages of the disease, or of a pure, virulent culture of the micrococcus, usually results in the death of these animals in from twenty-four to forty-eight hours. The course of the disease produced and the post-mortem appearances indicate that it is a typical form of septicæmia—so-called sputum septicæmia. The most marked pathological lesion is the enlargement of the spleen. The blood after death often contains large numbers of pneumococci. True localized pneumonia does not usually result from subcutaneous injections into susceptible animals, but injections made through the thoracic walls into the substance of the lung may induce a typical fibrous pneumonia. Attenuated cultures produce, according to the point of inoculation, pneumonia and pleurisy, peritonitis, etc. Attenuation of the virulence of cultures of the pneumococcus may be produced artificially by the action of heat or several days' growth in the incubator, by continued passage through unsusceptible animals (guinea-pigs), by cultivation in unsuitable media, etc. Virulence is restored and increased by passage through highly susceptible animals of the same species from which the organism was originally obtained.

The pneumococcus has not been found outside the body, except in sputum. It is frequently present in the saliva of healthy individuals. In diseased persons it is one of the most important pathogenic bacteria. It is associated with various inflammatory processes, especially of the mucous and serous membranes; and is the chief etiological factor in the production of lobar and catarrhal pneumonia, pleurisy, pericarditis, endocarditis, empyema, peritonitis, otitis, meningitis, conjunctivitis, and keratitis; less frequently of nephritis, parotitis, metritis, pyosalpinx, strumitis, amygdalitis, arthritis, osteomyelitis, periostitis, abscesses, and general septicæmia. Erysipelas can also be caused by it. In many of these affections the organism is found not only locally, but also in the blood. Very often the pneumococcus is associated with and acts as a synergist of other pus-producers, as the staphylococcus, streptococcus, etc.

It is carried from its original seat in the lungs to distant organs of the body by means of the circulation, being often found in the lymphatics and the blood both during life and after death. Knowing that the saliva and nasal secretions under normal conditions so frequently afford a resting place for the pneumococci, we have only to assume the production of a suitable medium for these parasites in the body, brought about by an abnormal condition of the mucous membranes from exposure to cold, or a reduction of the vital resistance of the tissue cells in an interior organ, by disease, traumatism, excesses of various kinds, alcoholism, etc., readily to comprehend how an individual may become infected primarily or secondarily with pneumonia.

Immunity.—Fraenkel has shown that subcutaneous injections of rabbits with virulent cultures of the pneumococcus produced infection in only a small proportion of them; those which recovered were found to be somewhat immune to a second infection. Artificially attenuated cultures or material containing naturally weakened micrococci have also been used for inoculation. Another series of experiments were based on the assumption that the protective substances are contained in the natural or artificial products of the growth of the organisms. Thus cultures freed from bacteria by filtration and emulsions of pneumonic sputum, portions of pneumonic lung, pleuritic exudates, etc., were employed for inoculation by different experimenters. But the quantity of material required for inoculation by these methods having been found inconveniently large, attempts have been made to obtain the immunizing products in a more concentrated form. Foà and Scabia, and the Klemperer brothers prepared glycerin extracts, after the manner of Koch's tuberculin, calling their product "pneumotoxin." At present, however, a protective serum is obtained from horses by the repeated injections of fully virulent pneumococci in exactly the same way as in the production of antistreptococcus or diphtheritic antitoxic serum.

Curative experiments in man have been recently made with this antipneumococcus serum obtained from immunized animals. The most successful of these were conducted by the Klemperers. They hold that in man during the pneumonic process there is a constant absorption into the circulation of the toxic substances produced by the bacteria. This continues until eventually the same antitoxic substance is produced naturally in the body as is seen to occur experimentally. It is then, they think, that the crisis takes place. The bacteria are neither destroyed nor is their power to produce pneumotoxin lessened; but the third factor, the antitoxin, now exists and neutralizes the toxin. These authors state that they have been able to show that the blood serum of patients after the crisis contains antitoxic substances, and is capable, in a fair number of cases, of curing the disease when injected into infected animals. They have also made observations upon patients with a view of inducing the crisis by the injection of the blood serum of immunized animals and of persons convalescent from pneumonia. Somewhat favorable results have been reported in a certain number of cases thus treated by the Klemperers, Jansen, De Rienzi, Weisbäcker, Washburn, Passé, Ugheti, Mennes, Lambert, and others, but nothing definite so far has been accomplished. It may, therefore, be concluded that the curative treatment by antipneumococcus serum, like that of antistreptococcus serum, is still in the experimental stage. All that can be said about the results obtained is that the cases treated have, as a rule, done better than was expected, though no striking curative effects have been produced. In many instances there was no development of pneumococcus blood infection; and even if the serum does not hasten the crisis and bring about a positive cure, yet it may be able to prevent a general infection. It is known that there are several varieties of the pneumococcus, as of the streptococcus, possessing different biological and pathological properties and varying virulence. Possibly it may be found that pneumococcus serum obtained from animals immunized against a certain variety of pneumococcus protects only fully against that variety, as with the streptococcus serum. But whether that be so or not, the injections, at any rate, of the serum have been shown to be practically harmless, and the benefits to be derived from the discovery of a curative remedy for pneumonia

EXPLANATION OF
PLATE XI.

EXPLANATION OF PLATE XI.

FIG. 1.—Bacillus Coli Communis. Agar culture. Stained with fuchsin. × 1,000. Photomicrograph from Bowhill's "Bacteriology" by permission.

FIG. 2.—Streptococcus Pyogenes (Longus). × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 3.—Staphylococcus Pyogenes Aureus. × 1,000. Photomicrograph from Park's "Bacteriology" by permission.

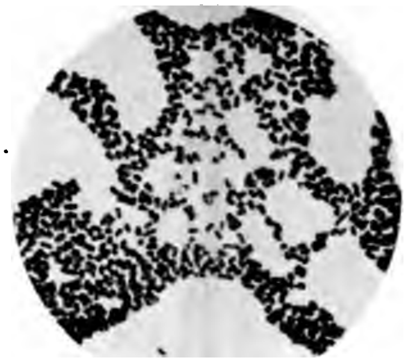
FIG. 4.—Micrococcus Tetragenus (Tetracoccus). × 1,000. Photomicrograph from Park's "Bacteriology" by permission.

FIG. 5.—Diplococcus Pneumoniæ (Fraenkel) in Sputum. × 1,000. Stained by Gram's method. Photomicrograph from Sternberg's "Bacteriology" by permission.

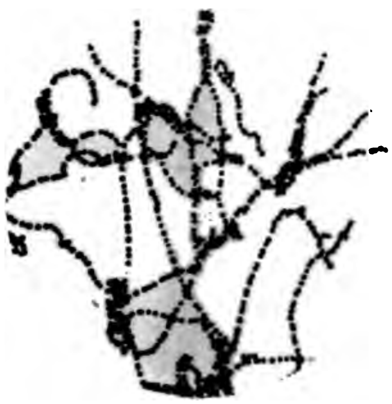
FIG. 6.—Diplococcus Pneumoniæ (Fraenkel) in Blood. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 7.—Micrococcus Gonorrhœæ (Gonococcus Neisser) in Urethral Pus. Stained with Loeffler's solution of methylene blue. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

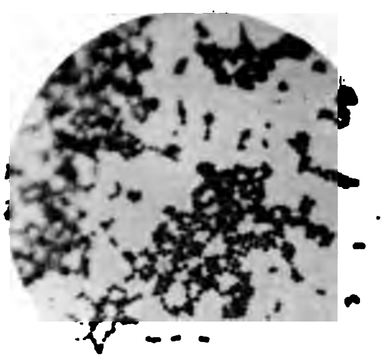
FIG. 8.—Diplococcus Intracellularis Meningitidis (Meningococcus). × 1,000. Photomicrograph from Park's "Bacteriology" by permission.



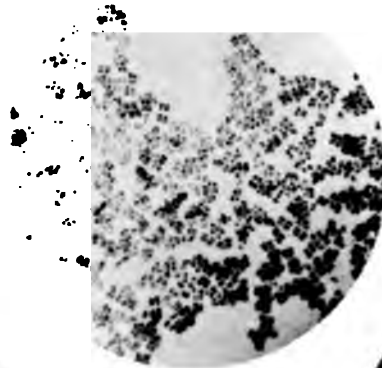
I.
Bacillus Coli Communis.



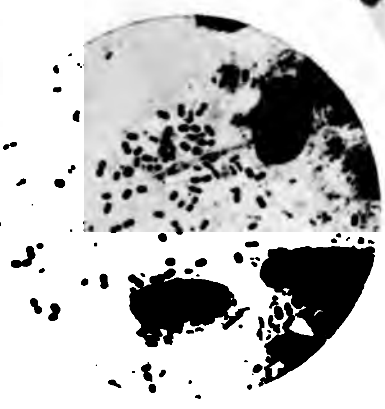
II.
Streptolococcus pyogenes.



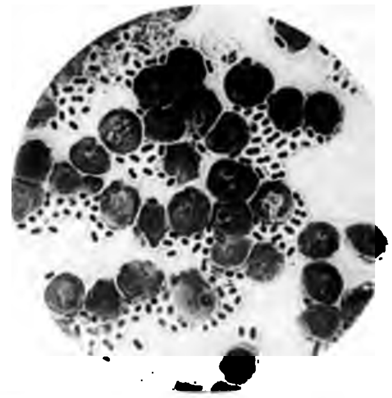
III.
Staphylococcus pyogenes aureus.



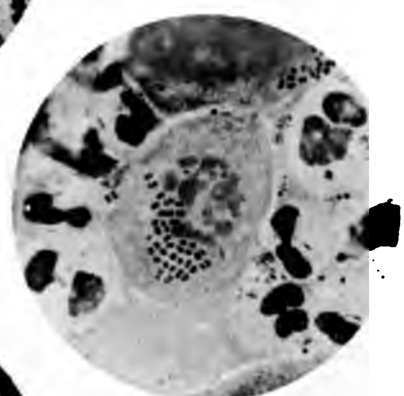
IV.
Tetracoccus.



V.
Diplococcus pneumoniœ in sputum.



VI.
Diplococcus pneumoniœ in blood.



VII.
Gonococcus (Neisser).

VIII.
Diplococcus Intracellular meningitidis.

Pathogenic Bacteria.

are so great that these experiments are certainly worth continuing.

THE MENINGOCOCCUS (*Diplococcus Intracellularis Meningitidis*).—This organism was isolated by Weichselbaum (1887) from the exudate of cerebro-spinal meningitis, both when complicating pneumonia and in uncomplicated cases, and from its usual presence in the interior of pus cells he called it *diplococcus intracellularis*. It has since been found (1895) by Jäger and Scheurer in the nasal secretions and sputum of persons suffering from this affection during an epidemic. The frequency of its occurrence in and restriction to this disease afford sufficient evidence of its being concerned at times, at least, in the production of cerebro-spinal meningitis, though the pneumococcus is probably the most common cause.

Motility.—Non-motile.

Staining Reactions.—Stains with the ordinary aniline colors, but best with Loeffler's alkaline methylene blue.

Microscopical Appearances.—Occurs as coffee-bean-shaped micrococci usually united in pairs (diplococci), but also in groups of four, and in small masses; sometimes solitary and smaller apparently degenerated forms are found. In the exudate it is generally found, like the gonococcus, to which it bears a close resemblance morphologically, in the interior of the pus cells and extra-nuclear. According to some authors it is sometimes indistinguishable in form from the pneumococcus, streptococcus pyogenes, and tetracoccus. (See Plate XI., Fig. 8.)

Biological Characters.—The meningococcus does not grow at room temperature but only in the incubator at 36°-37° C. Its development is usually scanty on the surface of agar, though sometimes a few colonies grow luxuriantly. It does not grow at all or very poorly in bouillon or bouillon mixed with one-third blood serum. It develops best on Loeffler's blood-serum mixture as used for diphtheria cultures.

When grown on *nutrient* or *glycerin agar*, at the end of forty-eight hours in the incubator a tolerably good growth develops, appearing as flat, grayish colonies, viscid and usually non-confluent. On *Loeffler's blood serum* the growth forms round, whitish, shining, viscid-looking colonies, with smooth, sharply defined outlines. The colonies tend to become confluent, but do not liquefy the serum.

Cultivated in artificial media the meningococcus soon loses its vitality (in six days), and must therefore be transplanted every two or three days to fresh media.

Pathogenesis.—Not very pathogenic for animals; most so for mice and guinea-pigs, less so for rabbits and dogs. Subcutaneous injections of animals give negative results; intrapleural or intraperitoneal inoculations in mice and guinea-pigs, in large doses, are generally successful. The animals usually fall sick and die within thirty-six to forty-eight hours, showing slight fibro-purulent exudation. In the blood and enlarged spleen diplococci are found in small numbers and mostly free; in the pleuritic exudate they are present in considerable quantities and then are found in the interior of the pus cells. Meningitis, corresponding to the disease as occurring in man, has been artificially produced in dogs by subdural inoculations of recent cultures.

Under natural conditions in the human subject the meningococci probably gain access to the brain and meninges by way of the nose, ear, and upper air passages. They have been found not only in meningeal pus but also in the nasal mucous secretions, the sputum and the urine of patients suffering from meningitis, and occasionally in the nares of healthy persons coming in contact with patients. A mixed infection of the meningococcus, pneumococcus, and streptococcus pyogenes is often met with.

A bacteriological diagnosis of cerebro-spinal meningitis may often be made by means of lumbar puncture to obtain a specimen of the fluid from the spinal canal, and microscopical examination and cultivation on Loeffler's blood serum. The clinical value of this is, that about forty per cent. of the cases due to the meningococcus recover, while almost all of those caused by the pneumococcus and streptococcus die.

THE GONOCOCCUS (*Micrococcus Gonorrhœæ*).—First observed by Neisser (1879) in gonorrhœal pus and described by him under the name of "gonococcus." It was obtained in pure culture by Bumm (1885), and its infective nature proved by inoculations into men.

Microscopical Appearances.—Micrococci usually united in pairs (diplococci) or groups of four. The bodies of the diplococci are shaped like coffee beans or a Vienna roll (Semel), having an unstained division or interspace, in stained preparations, between two flat surfaces facing one another. They are from 0.8 to 1.6 μ long and 0.6 to 0.8 μ broad. In gonorrhœal discharges the diplococci are found mostly in small, irregular groups in or upon the pus cells and extra-nuclear. Occasionally round, single, and undivided cells are observed, and again irregular forms, particularly in old cultures, and in chronic gonorrhœa of long standing. (See Plate XI., Fig. 7.)

Motility.—Non-motile.

Staining Reactions.—Stains readily with the basic aniline dyes, especially with methyl violet, gentian violet, and fuchsin; not so quickly with methylene blue, which, however, is the best staining agent for demonstrating its presence in pus. The gonococcus is decolorized by Gram's solution, which enables it to be distinguished from other pus cocci; but this method cannot always be depended on to differentiate it from all diplococci found in the urethra and vulvo-vaginal tract, some of which are morphologically similar to the gonococcus and are also decolorized by Gram's solution.

Biological Characters.—Aërobic and facultative anaërobic. Does not grow at room temperature, best at 37° C. Growth on ordinary culture media is so scanty that special media have been devised for its cultivation.

Human Placenta Serum Agar.—Wertheim has succeeded in developing luxuriant and virulent cultures to many generations on a mixture consisting of placenta blood serum and two per cent. peptone agar. His method is as follows: Several loops of gonorrhœal pus are diffused through liquid placental blood serum warmed to 40° C. in a test tube. Two dilutions are made from this, and an equal quantity of melted two-per-cent. peptone agar cooled to 40° C. is added to the three tubes, and the contents poured into Petri dishes. At the end of twenty-four hours in the incubator there will have developed on at least one of the plates distinct colonies, which are in appearance translucent and finely granular with scalloped margins. By transferring such a colony to slant cultures of serum agar, pure cultures of the gonococcus are obtained; these are somewhat shiny in appearance and of a grayish-white color.

Human Chest Serum Agar.—Heiman, and almost simultaneously, Kiefer and Menge, proposed a culture medium made from hydrothorax, ascitic or hydrocele fluid, obtained from the human subject. This medium as prepared by Heiman consists of a 2 per cent. agar + 2 per cent. peptone + 0.5 per cent. salt + 2 per cent. glucose; of this mixture two parts are added to one part of "chest serum," obtained from a patient suffering from hydrothorax, acute pleurisy, or hydrocele, which, if necessary, is sterilized. The chest serum agar should have a neutral reaction. The growth in this medium is thus described: "In plate cultures streaked on the surface, growth abundant, colonies circular in shape, edges somewhat irregular, shading off into yellowish white; texture finely granular in periphery, presenting punctuated spots of higher refraction in and around the centre of yellowish color."

Pig Serum Nutrose Agar.—Wassermann recommends a culture medium for the gonococcus consisting of 15 c.c. pig serum diluted with 30–35 c.c. water, to which is added 2–3 c.c. glycerin, and finally about 2 per cent. nutrose (casein sodium phosphate). This is thoroughly mixed and boiled and sterilized by the fractional method. To the mixture is now added an equal quantity of 2 per cent. agar cooled to 40° C., for the inoculation of cultures, and then poured into Petri dishes. The growth is favored

by admission of air, and is similar in appearance to that already described for plate and streak cultures.

Toxins.—Wassermann has obtained on his serum nutrose agar virulent cultures of the gonococcus, which after being killed still possessed toxic action. The gonotoxin produced was found to be very resistant to heat and the action of alcohol; it killed mice, and in rabbits gave rise to caseous infiltration often passing into necrosis, and in large doses produced general toxæmia. Injected into the human subject the gonotoxin seemed to produce no curative effect on an existing chronic gonorrhœa, the intense reaction caused not becoming less on repeated inoculations.

The production of gonotoxin would seem to account for the gonorrhœal secretion. It also renders more comprehensible several obscure points in the history of chronic gonorrhœa: for example, the fact that gonococci may be apparently absent from, or only isolated organisms present in, the gonorrhœal discharge, and yet a purulent secretion be kept up containing few bacteria; but if, owing to some injury to the tissues, the organisms increase in number an acute exacerbation of the disease is again set up and masses of gonococci are then found in the pus.

Vitality.—The gonococcus has but little resistant power against outside influences. It is killed by weak disinfecting solutions and by desiccation in thin layers. In comparatively thick layers, however, as when gonorrhœal pus is smeared on linen, it has lived for forty-nine days, and dried on glass for twenty-nine days (Heiman). No development takes place below 25° C. or above 39° C.; it is killed by a temperature over 42° C.

Pathogenesis.—Gonorrhœa as occurring in man is non-transmissible to dogs, monkeys, horses, and rabbits, whether inoculations be made into the urethral, vaginal, or other mucous membranes. Large doses of virulent cultures produce in animals toxic inflammations, similar to that produced by the gonotoxin, without any multiplication of cocci. Although animal inoculations have been thus followed by negative results, the etiological relation of the gonococcus to human gonorrhœa has been demonstrated beyond question by the infection of healthy men with the disease by inoculation of pure cultures by Bumm, Wertheim, Kiefer, and Heiman.

The gonococcus has never been found outside the body, except in articles of clothing, etc., which have become contaminated by those affected with the disease; nor has it ever been met with in healthy persons. In those suffering from gonorrhœa it has been found in the urethra and prostate of the male and in the urethra, vagina, and cervix uteri of the female, as the cause of the disease. Besides gonorrhœal urethritis and vaginitis, the gonococcus is the cause of certain cases of endometritis, metritis, salpingitis, oöphoritis, peritonitis, proctitis, cystitis, and probably also of epididymitis; also of gonorrhœal ophthalmia neonatorum, and rarely of diphtheritic conjunctivitis in children (Fraenkel). The gonococcus produces in adults severe conjunctivitis, seldom rhinitis and otitis. It is frequently the cause of gonorrhœal arthritis, also probably in some cases of pleuritis, malignant endocarditis, parotitis, periostitis, and bursitis.

In the local affection squamous epithelium protects better than cylindrical epithelium. The parasite penetrates gradually through the epithelium into the connective tissue. In travelling to distant organs of the body the gonococcus follows mainly the course of the lymphatics and produces inflammation which finally leads to fibrinous hypertrophy—stricture of the urethra, hypertrophy of the prostate, etc. There is no immunity produced after recovery from an infection.

In view of the fact that several non-specific forms of urethritis exist, and also that diplococci morphologically similar to the gonococcus Neisser are often found in the normal urethra and vulvo-vaginal tract, it becomes a matter of great importance to be able to detect gonococci when present and to differentiate these from the non-specific organisms. For the demonstration of gonococci, they must be found as diplococci lying in masses in the pus cells and extra-nuclear, when stained with methylene blue and decolorized by Gram's solution. Organisms having these characteristics microscopically may for all practical purposes be considered as certainly gonococci, if they are obtained from the urethral discharge and confirmed by examination on three successive days. But if there still remain any doubt, and especially if the organisms are obtained from the vulvo-vaginal tract, plate cultures should be made on one of the special media described (chest serum agar, etc.), on at least three consecutive days.

THE BACILLUS PYOCYANEUS (*Bacillus of Green and Blue Pus*).—This bacillus is found in green or blue colored pus which occasionally accompanies the discharges from open wounds, and is the cause of the pigmentation produced.

Microscopical Appearances.—Delicate, slender rods, about 0.4 μ broad and 1.5 to 6 μ long, often united in pairs or in chains of four to six elements, and occasionally growing into long threads.

Motility.—Actively motile, possessing only one flagellum.

Spore Formation.—Absent.

Staining Reactions.—Stains readily with the ordinary aniline colors; does not stain with Gram's method.

Biological Characters.—Aërobic and facultative anaërobic, but produces pigment only in the presence of oxygen. Grows readily on all artificial culture media at room temperature, but best at 37° C. On *gelatin plates* flat, irregular colonies with radiating borders are rapidly developed, imparting to the medium a fluorescent green color; liquefaction begins at the end of two or three days, and in five days the gelatin is completely liquefied. *In gelatin stab cultures* liquefaction takes place rapidly at first near the surface and gradually extends downward; a greenish color is produced in that portion in contact with the air. On *agar plates* a wrinkled, moist, whitish layer is developed, the surrounding medium being at first bright green, later darker in color, and finally blue green or almost black. In *bouillon* a green fluorescence is produced, the medium being clouded, and a flocculent sediment forms. *Milk* is coagulated and peptonized. On *potatoes* a greenish-yellow or brownish growth occurs, the surrounding surface being green.

The bacillus pyocyaneus produces two pigments—one of a fluorescent green (*bacterio-fluorescin*, soluble in water) and the other of a blue color (*pyocyanin*, soluble in chloroform) formed only in the presence of oxygen. A faint aromatic odor is produced in recent cultures; in old cultures a disagreeable ammoniacal odor. No indol or H_2S is formed by this bacillus, and very little acid from grape sugar; no gas. Nitrates and nitrites are converted into free nitrogen. The bacillus pyocyaneus produces poisons by its growth. It has but little resistance to outside influences. Drying kills it rapidly; exposure to the action of direct sunlight for four hours partly destroys its power of producing pigment.

Pathogenesis.—Pathogenic for rabbits and guinea-pigs. Subcutaneous or intraperitoneal injections of 1 c.c. of a bouillon culture cause the death of these animals in from twenty-four to thirty-six hours, with the production of extensive inflammatory œdema and purulent infiltration of the tissues. The bacilli multiply in the body, and may be found in the serous or purulent fluid as well as in the blood and organs. Smaller amounts do not kill the animals, but render them immune to doses fatal to those not thus immunized. In rabbits inoculated with a culture of the bacillus anthracis a fatal result may be prevented by soon after inoculating the animal with a pure culture of the bacillus pyocyaneus. It has been suggested that the protective action is due to the chemical products of the growth of the bacillus, and not to an antagonistic effect of the living bacteria.

Though widely distributed in nature, the bacillus pyocyaneus has not so far been found outside the living body. It has been observed occasionally in the mouth and intestines of healthy individuals, on the unbroken skin and in the purulent discharges of open

wounds, also in bandages and dressings, at times epidemically in hospitals. Usually the organism appears only in association with the common pus cocci, coloring the pus blue or green. In some cases, however, it has been found alone in disease processes, as in otitis media, ophthalmia, broncho-pneumonia, pericarditis, etc., especially in children, so that we have reason to believe that this bacillus, although ordinarily non-pathogenic for man, may under certain conditions become a source of infection. In general its presence in wounds delays the process of repair and may give rise to a depression of the vital powers from the absorption of its toxic products.

THE BACILLUS PROTEUS VULGARIS.—This is the most important of a group of similar bacteria, known as the "Proteus group," which are among the commonest and most widely distributed putrefactive organisms. They were formerly included by the earlier observers under the name of "bacterium termo," which they applied to all minute motile organisms found in putrefying substances.

Microscopical Appearances.—Small, slender rods varying greatly in size, but on the average about 0.6 μ broad and 1.2 μ long, generally occurring in pairs but sometimes arranged in filaments, which may be more or less twisted. It is to its great variability in form that it was given the name of *proteus*.

Motility.—Actively motile.

Spore Formation.—Absent.

Staining Reactions.—Stains readily with aniline dyes, especially fuchsin or gentian violet; also stains with Gram's solution.

Biological Characters.—Aërobic and facultative anaërobic. Grows on almost all culture media, developing most rapidly at room temperature, but also in the ice box and in the incubator. Toxin production seems to be favored by admission of air.

The growth on *gelatin plates* containing five per cent. of gelatin is very characteristic. At the end of ten to twelve hours at room temperature, small, round, yellowish colonies with thick centres and irregular edges develop, from which brush-like offshoots are thrown out. Other colonies are surrounded by a zone of threads which, partly in circular, partly in irregular twisted figures, surround the central opaque mass. Straight and twisted offshoots, which frequently become detached from the parent colony, grow into the surrounding medium and continue moving about in the liquefied gelatin, sometimes called "swarming islands." When the consistency of the medium is more solid, as in ten-per-cent. gelatin, the liquefaction and migration of these surface colonies are more or less retarded. In *gelatin stab cultures* the growth is less characteristic—liquefaction takes place rapidly along the line of puncture, and soon the entire medium is liquefied. Upon *nutrient agar* a rapidly spreading, thin, moist, grayish-white coating appears, and migration of the colonies also occurs. *Milk* is coagulated with the production of acid. On *potato* a dirty grayish coating develops. *Bouillon* is uniformly clouded.

Culture media containing albumin or gelatin are decomposed by the proteus vulgaris with the production of a disagreeable putrefactive odor and alkaline reaction. It produces gas and acid from carbohydrates, thus giving off no odor. It also produces indol and H_2S. Urea is decomposed into carbonate of ammonia. It forms toxins, which may be obtained by filtration of the cultures through porcelain. The proteus vulgaris possesses considerable resistance toward chemical and thermic influences, but is killed at 60° C. in half a minute.

Pathogenesis.—This bacillus is pathogenic for rabbits and guinea-pigs when injected intravenously, intraperitoneally, or subcutaneously in large quantities, death of the animal being produced with symptoms of intoxication. The effects are much more readily produced when other organisms, as the streptococcus, are introduced simultaneously into the body. Less virulent species of pathogenic bacteria (staphylococcus, streptococcus) also gain in virulence when they are injected along with living or dead proteus cultures.

The proteus vulgaris is found very commonly outside the body in putrid meat and other decaying substances, such as foul water, etc. It is found also in the digestive tract of healthy persons. In disease, it is the organism chiefly concerned in the production of cystitis with ammoniacal urine, either alone or in conjunction with the bacillus coli communis, and is also an etiological factor in many other genito-urinary affections. The *urobacillus liquefaciens septicus* of some authors is probably identical with the proteus vulgaris. Although this bacillus, however, occurs quite frequently, along with other bacteria in various diseases, it has seldom been positively shown to be the specific cause of infection. Booker, who has made extended investigations into the etiology of cholera infantum, concludes that the proteus vulgaris plays an important part in the production of this affection. He found the bacillus present in eighteen cases of cholera infantum examined by him, but not in the fæces of healthy infants. Levy believes that in so-called "meat or sausage poisoning" bacteria of this group are chiefly concerned, and that the pathogenic effects are due to toxic products evolved during their development; though others attribute this affection to an anaërobic organism, the *bacillus botulinus* of Van Ermengen, the symptoms being described as *botulism*. According to Jäger, certain forms of icterus accompanied with fever, pain in the muscles, and enlarged liver and spleen, known as "Weil's disease," are produced by the proteus. Thus it would seem that, though ordinarily a harmless parasite, the proteus vulgaris may at times become pathogenic to man. Considering the very wide distribution of this organism in nature, the wonder is that with its poisonous properties so few diseases apparently are produced by it.

THE BACILLUS OF MALIGNANT ŒDEMA (*Bacillus Œdematis Maligni; Vibrion Septique*).—This bacillus is widely distributed, being found in the superficial layers of the soil, especially in garden earth, manure, filth of all kinds, and house drains; also in the blood and intestines of animals. It was discovered by Pasteur (1877), and later carefully studied by Liborius and Koch.

Microscopical Appearances.—Rather large rods, similar morphologically to tetanus and symptomatic anthrax bacilli, but showing a greater tendency to grow out into long filaments; in size from 0.8 to 1 μ broad and 2 to 10 μ long.

Motility.—Motile, but not very actively so except the short forms, having three to twelve flagella attached to the ends and sides of the rods.

Spore Formation.—Forms spores generally in the middle of the rods and oval in shape.

Staining Reactions.—Stains readily with the ordinary aniline dyes, especially when obtained from the animal body; decolorized by Gram's method.

Biological Characters.—Strictly anaërobic, growing in all the usual culture media in the absence of oxygen. Development takes place at room temperature, but more rapidly and abundantly at 37° C.

This bacillus grows on *nutrient gelatin*, but more abundantly on glucose gelatin containing one to two per cent. of glucose. Gas is formed and the gelatin is liquefied.

On *agar plates* the colonies appear as dull, whitish points, irregular in outline, and when examined under a low power they are seen to be composed of a thick network of threads radiating irregularly from the centre to the periphery. *Blood serum* is rapidly liquefied, with the production of gas. *Bouillon* is clouded from the formation of gas. *Milk* is not coagulated. Cultures of the bacillus of malignant œdema give off a peculiar odor.

Pathogenesis.—Especially pathogenic for mice, guinea-pigs, and rabbits, although horses, cats, dogs, goats, sheep, calves, pigs, chickens, and pigeons are also susceptible, and occasionally man. Cattle are immune. A small quantity of a pure culture subcutaneously injected into a susceptible animal gives rise to general hemorrhagic œdema which extends over the entire surface of the abdomen and thorax and results in the death of the animal. There is no odor developed, and little, if any, gas. In infection with garden earth, owing to the presence of associated bacteria, gas is produced having a

putrefactive odor. Malignant œdema is chiefly confined to the domestic animals, but cases have also been reported in man. Infection takes place most readily when, as in the natural disease, other bacteria are simultaneously introduced, such as the B. proteus and the B. prodigiosus.

Animals which recover from malignant œdema are subsequently immune. Artificial immunity may be induced in guinea-pigs by the injection of filtered bouillon cultures which have been previously sterilized.

BACILLUS AËROGENES CAPSULATUS.—Found by Welch in the blood-vessels of a patient suffering from aortic aneurism; on autopsy made in cool weather eight hours after death, the vessels were observed to be full of gas. Since then it has been found in a number of other cases. These cases, as a rule, showed marked symptoms of delirium, rapid pulse, high temperature, and the development of emphysema and discoloration of the diseased area, or of abdominal distention when the peritoneal cavity was involved.

Microscopical Appearances.—Straight or slightly curved rods, with rounded or sometimes square-cut ends, somewhat thicker than the anthrax bacilli and varying in length, occasionally growing out into long threads. In the animal body, and sometimes in cultures, the bacilli are enclosed in a transparent capsule.

Motility.—Non-motile.

Spore Formation.—Absent.

Staining Reactions.—Stains with the ordinary aniline dyes and by Gram's method.

Biological Characters.—Anaërobic, growing at room temperature, but more rapidly at 37° C. in the usual culture media in the absence of oxygen, with gas production. *Gelatin* is not liquefied, but is gradually peptonized. On *agar* grayish-white colonies are developed in the form of flattened spheres, oval or irregular masses, beset with hair-like projections. *Bouillon* is diffusely clouded, and a white sediment is formed. *Milk* is rapidly coagulated.

Pathogenesis.—Usually non-pathogenic in healthy animals, although Dunham found that the bacillus taken freshly from human infection is sometimes very virulent. When quantities up to 2.5 c.c. of fresh bouillon cultures are injected into the circulation of rabbits and the animals killed shortly afterward, the bacilli develop rapidly with abundant formation of gas in the blood-vessels and organs, especially the liver. Welch suggests that in some cases in which death has been attributed to the entrance of air into the veins the gas found at autopsy may have been produced by this or some similar micro-organism entering the circulation and developing shortly before or after death. The bacillus has been found in the dust of hospital wards.

THE ANTHRAX BACILLUS (*Bacillus Anthracis; Milzbrand Bacillus; Bactéridie du Charbon*).—This organism is always present in the blood of animals affected with anthrax or splenic fever, an acute disease very prevalent, in certain parts of Europe and Asia, among sheep and cattle. In this country it is comparatively rare. The disease also occurs in man as the result of infection, either through the skin, the intestines, or, in rare instances, through the lungs, in the form of external anthrax or malignant pustule, and internal anthrax or wool-sorter's disease. Those persons are most subject to infection who come in contact with animals, hides, wool, etc.

Owing to the fact that anthrax was the first infectious disease which was shown to be caused by a specific micro-organism, the study of this bacillus has probably contributed more to our general knowledge of bacteria than any other living organism. It was first observed by Pollender in 1849 in the blood of animals affected with anthrax. In 1863 Davaine showed by inoculation experiments that it was capable of producing the disease. Then finally in 1879, Pasteur, Koch, and others demonstrated that the bacillus could be isolated in pure cultures on artificial media, and that when susceptible animals were inoculated with portions of these cultures conditions similar to those found in the animal from which the original cultures were obtained were produced.

Microscopical Appearances.—In the blood of animals it occurs as large rods of variable size, from 1 to 1.25 μ broad and 3 to 10 μ or more long, often arranged in flexible filaments twisted and plaited together. In unstained specimens examined in the hanging drop the ends of the rods appear to be slightly rounded, while in stained preparations they seem to be square cut. Under a high magnification, especially in cultures, the ends are seen to be a trifle thicker than the body of the cell, and occasionally somewhat indented and concave, giving to the rods the appearance of joints of bamboo cane. At one time much stress was laid upon these morphological peculiarities as distinguishing marks of the anthrax bacillus; but it has been found that they are the effects of artificial cultivation, staining, etc., and not necessarily characteristic of the organism under all conditions. The bacilli, when obtained from the blood of affected animals and certain culture media (liquid blood serum), are enclosed in a capsule, which in stained preparations may be distinguished by its taking on a lighter stain than the rods themselves which it surrounds. (See Plate XII., Fig. 1.)

Motility.—Non-motile.

Spore Formation.—Forms spores under aërobic conditions at temperatures from 12° C. up to 37° C. The spores are elliptical in shape and once or twice as long as broad; they first appear as small refractile granules distributed at regular intervals, one in each rod, and as the spores develop the mother cells become less and less distinct until they finally disappear altogether, the complete oval spore being set free by its dissolution. Spores are never formed in the living animal or in unopened carcasses, owing to lack of oxygen, but in slaughtered animals, bloody dung, etc., where the conditions necessary for their production exist. This fact is practically important with regard to the disposal of the carcasses of animals dead of anthrax. In fresh culture media the germination of spores takes place in a few hours. In old cultures which have been repeatedly transplanted the power of spore formation is often spontaneously lost. Certain varieties of anthrax bacilli soon become asporogenous. All agencies which decrease the virulence of the bacilli (as, for instance, cultivation at 42° C.) act unfavorably upon the function of spore formation. (See Plate XII., Fig. 2.)

Staining Reactions.—Stains easily with the ordinary aniline colors, also by Gram's method.

Vitality.—Anthrax bacilli free from spores retain their vitality in cultures for months, probably by spore production; in water they soon die; in the soil fresh anthrax blood is rendered germ free by exposure to sunlight in twelve to twenty-four hours. According to Koch, when exposed to desiccation, anthrax bacilli retain their vitality only for five weeks; in dried blood they withstand a temperature of 92° C. for one and one-half hours, but in the presence of oxygen they are killed by exposure to light in nine hours and in a vacuum in eleven hours. Pickling fails to destroy anthrax bacilli in meat in fourteen days, but kills them after six weeks. They are rapidly destroyed by moist heat at 60° C. Exposed to cold from 1° to 24° C. the bacilli in agar cultures were destroyed for the most part in twelve days, and the few surviving organisms yielded colonies of diminished pathogenic action and power of liquefying gelatin.

Dried anthrax spores retain their vitality indefinitely; in a moist condition in water, earth, putrid spleen, etc., the spores have lived for one and one-half to two and one-half years. They also resist a comparatively high temperature. Exposed to dry heat they require a temperature of 140° C. maintained for three hours to kill them, but in moist heat they are destroyed by a temperature of 100° C. in four minutes. Anthrax spores in a desiccated condition are killed by the action of direct sunlight in four hours, by diffuse daylight in several weeks.

Biological Characters.—Aërobic and facultative anaërobic, growing best in the presence of oxygen but also in its absence. Under the latter condition, however, this bacillus no longer liquefies gelatin, and the presence of oxygen is absolutely necessary for the formation of

spores. The anthrax bacillus grows rapidly on a variety of nutrient media at a temperature from 14° to 43° C., but best at 37° C.

Growth on Gelatin.—On *gelatin plates* small, white, opaque colonies are developed on the surface at the end of twenty-four to thirty-six hours at 24° C., while the deeper colonies are of a greenish color. Under a low power the colonies exhibit a characteristic appearance, consisting of a light-gray tangled mass of threads projecting beyond the edges in curly-hair-like tufts, which have been likened to a Medusa's head. Liquefaction of the gelatin takes place in three or four days, a white pellicle floating on the surface. In *gelatin stab cultures* at the end of twelve to twenty-four hours a thick, white central thread appears along the line of puncture, from which other white threads and irregular projections radiate perpendicularly into the medium. After two days liquefaction commences on the surface and gradually extends downward.

On *agar plates* the growth is similar to that on gelatin and is equally characteristic, but the colonies are not so compact. At the end of twenty-four hours in the incubator a grayish-white coating is formed on the surface, which spreads rapidly and consists of masses of long threads matted together.

In *bouillon* the growth is characterized by the formation of flocculent masses which sink as a sediment to the bottom of the tube, leaving the liquid clear.

Pathogenesis.—Especially pathogenic for mice, guinea-pigs, and rabbits, somewhat less for cattle and sheep (except the Algerian sheep, which are immune), and considerably less for horses; rats, cats, dogs, chicken, pigeons, and frogs are but little susceptible. Man, though subject to local infection (malignant pustule) from accidental inoculation of wounds, and occasionally to intestinal or pulmonary infection (wool-sorter's disease) as the result of inoculation through dust charged with anthrax spores and the consumption of meat from anthrax animals, is not as susceptible to this disease as the lower animals. Subcutaneous injections in susceptible animals result in death in from one to three days. Little or no change can be observed at the point of inoculation, but the subcutaneous tissue for some distance over the abdomen and thorax is found to be œdematous, with small ecchymoses scattered throughout the œdematous portion; the underlying muscles are pale in color. The intestinal viscera show no marked microscopical lesions, except the spleen, which is enlarged, soft, and dark colored. The liver may present the appearance of cloudy swelling. The lungs are red or pale red in color, while the heart is usually filled with blood. The anthrax bacillus produces in susceptible animals a true septicæmia, and after death the capillaries throughout the body always contain the bacilli in larger or smaller number. It is difficult to produce infection by the ingestion even of spores, but by inhalation it may be readily caused in animals. Infection is most promptly brought about by introduction of the bacilli directly into the circulation, but inoculation by contact with the abraded skin may also produce infection.

Many theories have been advanced to account for the occurrence of intestinal anthrax in cattle and sheep, the form of the disease which is most common in these animals. It has been thought that infection was produced mainly by the eating of food contaminated by anthrax spores derived originally from the bodies of affected animals; but, as we have seen, it is extremely difficult to cause infection in this way. By some authors it has been supposed to be a miasmatic infection and likened to malaria; and occurring as it does in the summer months and in low swampy places, there would seem to be a possible analogy in this respect between the two infections. But anthrax occurs in epidemics, being present at one time at a certain place and absent at another. Pasteur is of the opinion that the earth worms play an important part in conveying the spores from one locality to another from the buried carcasses of affected animals; but Koch has shown this hypothesis to be untenable, as the bodies of earth-worms offer an unsuitable medium for the growth of spores, even if they were taken up and carried in this way. The most plausible explanation so far suggested for the solution of the problem is the supposition that under natural conditions unfavorable to the development of the bacilli an attenuation of their virulence takes place, and then again as the conditions become more favorable the virulence is restored—a result which can be artificially produced in cultures by chemical agents, heat, etc. Nutall has recently suggested that perhaps the disease may be conveyed in the bodies of insects, under certain conditions, as with malarial infection; but here, too, the bacilli undergo attenuation, according to the same author.

Attenuation of Virulence and Immunity.—The virulence of anthrax cultures may be artificially attenuated by the action of chemical agents and heat. Pasteur has succeeded in effecting considerable immunity against anthrax in regions where this disease is prevalent, by the inoculation of cattle and sheep with cultures attenuated by heat. Two vaccines are employed of different degrees of strength, prepared from virulent cultures reduced in virulence by cultivation at temperatures between 42° and 43° C. According to statistics collected by Chamberland from the results of twelve years' experience with this method of protective inoculation in France, out of three million sheep thus treated only one per cent. have died of anthrax since its introduction, whereas the mortality previously was over ten per cent. In cattle the mortality percentage has been reduced from five per cent. to 0.3 per cent. The method, however, is not unattended with danger, and sometimes the animals succumb to the effects of the inoculation.

THE BACILLUS OF SYMPTOMATIC ANTHRAX (*Bacillus des Rauschbrands ; Bactéridie du Charbon Symptomatique*).—Like the bacilli of anthrax, of malignant œdema, and tetanus, to all of which it bears a certain resemblance, the bacillus of symptomatic anthrax is an inhabitant of the soil. It is the specific cause of the disease in animals, principally cattle and sheep, known as "black-leg," "quarter-evil," or symptomatic anthrax, which prevails in certain localities, and is characterized by a peculiar emphysematous swelling of the tissues of the leg and quarters, accompanied with the formation of gas. On section of the affected parts the muscles and cellular tissues are found saturated with bloody serum, while the tissues themselves are dark, almost black in color. The bacillus can always be found in the affected parts, in the gall and after death in the internal organs.

Microscopical Appearances.—Long rods, with rounded ends, from 0.5 to 6 μ broad and 3 to 5 μ long; mostly isolated, also occurring in pairs, joined end to end, but never growing out into long filaments, as the anthrax bacillus does in culture media and the bacillus of malignant œdema in the animal body.

Motility.—Actively motile, flagella being attached to the bodies of the cells.

Spore Formation.—Forms spores elliptical in shape, usually thicker than the bacilli, lying near the middle of the rods, but rather toward one end, giving them a spindle shape.

Staining Reactions.—Stains with the ordinary aniline dyes, but not with Gram's method or only when the staining is much prolonged.

Biological Characters.—Strictly anaërobic, growing only in the absence of oxygen, best in an atmosphere of hydrogen but not in CO_2. Develops at room temperature in the usual culture media, but best in media containing 1.5 to 2 per cent. glucose or 5 per cent. glycerin and at 37° C.

On *gelatin*, irregular, slightly lobulated colonies develop and the gelatin is soon liquefied. On *agar* the colonies are similar to those of malignant œdema but somewhat more compact, after twenty-four to forty-eight hours in the incubator. In agar stab cultures growth occurs some distance below the surface, and is accompanied by the production of gas having a peculiar, disagreeable, rancid odor.

Pathogenesis.—Pathogenic for cattle (which are im-

mune against malignant œdema), sheep, goats, guinea-pigs, and mice; less so for horses and rats. Rabbits, pigs, cats, dogs, chickens, and pigeons are, as a rule, immune. Infection has never been produced in man.

When susceptible animals are inoculated subcutaneously with pure cultures of this organism, with spores or with bits of diseased tissue, death occurs in from twenty-four to thirty-six hours. At the autopsy a bloody serum is found in the subcutaneous tissues extending over the entire surface of the abdomen, and the muscles present a dark red or black appearance, even more intense in color than in malignant œdema, and there is considerable development of gas.

The ordinary manner of natural infection in cattle is by wounds which not only tear the skin, but penetrate the subcutaneous tissues. The disease is also produced by the ingestion of forage contaminated by the bacilli or their spores, and by the inhalation of dust containing the organisms.

Immunity.—It is well known to veterinarians that natural recovery from one attack of symptomatic anthrax protects an animal from a second attack. Artificial immunity can also be produced in various ways: by intravenous inoculation; or, in guinea-pigs, by inoculations with bouillon cultures which have been kept for a few days and have lost some of their virulence, or with cultures kept in the incubator at 42° to 43° C.; or by inoculations made into the end of the tail; or by injection of filtered cultures or cultures sterilized by heat. Arloing, Cornevin, and Thomas recommend for the production of immunity in cattle the use of a dried powder of the muscles of animals dead of the disease, which has been subjected to a temperature sufficient to attenuate its virulence. Two vaccines are prepared, as in anthrax, one by exposure of the powder to 85°–90° C. (the stronger vaccine), and the other to a temperature of 100°–104° C.; the weaker vaccine is first used, and then the stronger. The inoculation is made into the cellular tissue of the ear or on the end of the tail; fourteen days are allowed to elapse between the two inoculations. Kitt recommends a single vaccine from infected flesh heated for six hours at 100° C. and given in decigram doses. The results obtained from these methods of preventive inoculation against symptomatic anthrax would seem to have been fairly satisfactory.

THE SPIRILLUM OF ASIATIC CHOLERA (*Koch's Comma Bacillus*).—In 1883 Koch isolated from the dejecta and intestines of patients suffering from Asiatic cholera a characteristically curved organism—the so-called "comma bacillus"—and showed that these bacteria were exclusively found in cases of the genuine disease. Other observers have since described morphologically similar organisms of non-choleraic origin. Finkler and Prior, for instance, observed such organisms in the diarrhœic stools of patients with cholera nostras; Deneke found others in old cheese, Miller met with others again in carious teeth, and Metschnikov observed others in fowls. But all of these organisms differ in many respects from Koch's comma bacillus, and none of them is affected by the specific serum of animals immunized to Asiatic cholera. Though varying somewhat in different epidemics, this spirillum is now generally recognized by bacteriologists to be the chief etiological factor in the production of true Asiatic cholera.

Microscopical Appearances.—Curved rods, with rounded ends which do not lie in the same plane, from 0.8 to 2 μ in length and about 0.4 μ in breadth. The curvature of the rods may be very slight, like a comma, but sometimes it forms a half-circle, or two contact rods curved in opposite directions may form an S-shaped figure, and under unfavorable conditions of growth, as in old cultures and on the addition of chemical antiseptics, etc., they may develop into long spiral filaments consisting of numerous turns of a spiral in which it is impossible to recognize any connection between the individual elements of which they are composed. These latter, the true spirilla, are considered to be involution forms. Under favorable conditions of growth and in fresh cultures, the slightly curved or almost straight forms are commonly observed. (See Plate XII., Fig. 5.)

Motility.—Actively motile, the movements being undulatory and due to one or two flagella attached to the ends of the rods.

Spore Formation.—Absent; the arthrospores described by Hueppe have not been confirmed by other observers.

Staining Reactions.—Stains with the ordinary aniline colors, but not as readily as many other bacteria: an aqueous solution of carbol fuchsin gives the best results with the application of heat. It is decolorized by Gram's method.

Biological Characters.—Aërobic and facultative anaërobic, growing on all the usual culture media at room temperature, but best in the presence of oxygen at 37° C. There is no development below 8° C. or above 42° C. The culture media must be distinctly alkaline, as the spirillum is very sensitive to acid.

On *gelatin plate cultures* at 22° C., at the end of twenty-four hours, small, round, yellowish-white to yellow colonies may be seen in the depths of the medium, which later grow toward the surface and cause liquefaction of the gelatin, the colonies sinking to the bottom of the pockets thus formed. Examined under a low power they appear granular in structure with more or less irregular outlines, the surface looking as if covered with little fragments of glass. An ill-defined halo is first seen to surround the colonies, which has a peculiar reddish tint by transmitted light. In *gelatin stab cultures* at the end of twenty-four to thirty-six hours a small funnel-shaped depression appears on the surface of the medium, which soon spreads out in the form of an air bubble above, while below this a whitish, viscid mass is seen. The funnel now increases in depth and diameter, and in from four to six days may reach the edge of the tube; in from eight to fourteen days the upper two-thirds of the gelatin is liquefied; and in a few weeks complete liquefaction takes place.

Upon *agar plates* the growth is not so characteristic, a moist, shining, grayish-yellow coating developing on the surface in the incubator.

Blood serum is rapidly liquefied at brood temperature.

In *bouillon* the growth is rapid and abundant, the liquid being diffusely clouded, and on the surface a wrinkled membranous film is often formed.

On *potato* having an acid reaction no growth, as a rule, takes place; but if the potato be rendered alkaline with a solution of soda or cooked in a three-per-cent. solution of common salt, development takes place in the incubator as a thin, semi-transparent brown or grayish-brown layer.

Milk is a favorable culture medium, but is not changed, as a rule, though it is coagulated by some varieties of cholera spirilla.

Vitality.—The comma bacillus does not usually exhibit much resistance to outside influences. In patients suffering from the disease the organisms have, as a rule, disappeared from the contents of the intestines in from four to eight or more rarely in from ten to fifteen days; though in a few cases living spirilla have been found after forty-seven days. They have been observed in cholera dejections from one to three, and occasionally from twenty to thirty days; in one recorded case after one hundred and twenty days. Even in cultures the spirilla of Asiatic cholera are rather short-lived. They have been found, however, to retain their vitality in pure bouillon cultures for three or four months and in agar cultures for six months or more, when protected from drying. In unsterilized water they may live for a considerable time apparently, though the observations on this vary from one day to one year. In sterile water they develop to some extent and retain their vitality for several weeks. Low temperatures, absence of light, and presence of salt in the medium would seem to favor their preservation. In well or river water they usually die in from three to eight days. In food they retain their virulence for a period varying from a few hours to a few days.

The comma bacilli are rapidly destroyed by desiccation. Exposed in cultures on a cover glass to the action of the

air at room temperature they are killed in two or three hours unless spread in a very thick layer. This fact indicates that infection is probably not usually produced through dust or other dried objects contaminated with cholera bacilli. They are destroyed by moist heat at 60° C. in ten minutes. They resist cold fairly well, withstanding repeated freezing without being killed, though their growth is inhibited. They have but little resistance to the action of chemicals, especially mineral acids, which have thus been employed for the disinfection of waterworks to which these germs have gained access. For disinfection on a small scale 0.1-per-cent. solution of bichloride of mercury or two to three per-cent. solution of carbolic acid may be used. Milk of lime is a good general disinfectant on a large scale. The wash and linen of cholera patients, floors of dwellings, etc., may be disinfected by a five-per-cent. solution of carbolic acid and soap water.

Chemical Effects.—The spirilla choleræ produce pigment in small amount only on potato. The peculiar disagreeable odor given off from cholera cultures in bouillon has been thought by some to be of diagnostic value, but it is not specific. Milk sugar is decomposed with the production of lactic acid without gas. In lactose-litmus agar the cholera spirillum forms on the surface of the medium a blue film, below this a red coloration, while lower down the medium is decolorized.

When a small quantity of chemically pure sulphuric acid is added to a twenty-four-hour-old bouillon culture of the cholera spirillum containing peptone, a reddish-violet color is produced—known as the "nitroso-indol reaction"—which is due to the production of indol and the reduction of nitrates in the culture to nitrites. Brieger separated the pigment thus formed or "cholera red." For a long time it was believed that the nitroso-indol reaction was peculiar to the cholera spirillum, and great weight was placed upon its production as a diagnostic test. But it has been shown that it is by no means specific, many other bacterial species giving the same reaction under similar conditions. The reaction, nevertheless, is a constant and characteristic property of this bacillus, and is of undoubted value in differentiating this from other similar organisms which do not give the reaction. For the test it is best to employ a culture not of bouillon, but a distinctly alkaline solution of peptone (1 per cent. peptone + 0.5 per cent. sodium chloride—Dunham's solution), from which more constant results are obtained.

Several toxins have been obtained from cholera cultures, but all of them much less poisonous than the original cultures. According to Pfeiffer these toxins are to be considered as secondary products modified by the action of the chemical reagents employed in separating them. Very much more powerful toxic products have been obtained from the bodies of the bacilli cultivated on agar and carefully killed by chloroform or heat. Three times the minimal fatal dose thus obtained from an agar culture (about 0.5 mgm.) kills a guinea-pig in from sixteen to eighteen hours, when injected into the peritoneal cavity, the effect being exactly the same as that produced by the living organisms, viz., rapidly beginning symptoms of the algid stage, muscular weakness, collapse, and death.

Pathogenesis.—None of the lower animals being naturally subject to Asiatic cholera, there is little reason to expect that inoculations of pure cultures of the spirillum should give rise to typical cholera infection. It has been shown, moreover, that the comma bacillus is extremely sensitive to the action of acids, being quickly destroyed in the stomach by the acids of the gastric juice. Nevertheless, numerous attempts have been made to produce cholera in test animals by inoculation of pure cultures of the organism, usually with negative or unsatisfactory results. Koch, however, has succeeded in producing an approximation, at least, to the symptoms of cholera in man by the infection of guinea-pigs by the following method: First, 5 c.c. of a five-per-cent. solution of sodium carbonate are injected into the stomach by means of a pharyngeal catheter, in order to neutralize the gastric contents; and then, after a while, 10 c.c. of a liquid containing one or two drops of a bouillon culture of the bacillus is administered in a similar manner, and at the same time the animal receives 1 c.c. of laudanum intraperitoneally, per 200 gm. weight, to control the peristaltic movements. As the result of this treatment the animals are narcotized for about half an hour, but recover without showing any ill effects from the opium. In about twenty-four hours the temperature begins to fall, weakness and paralysis set in, and, as a rule, death occurs within forty-eight hours. On autopsy the intestines are found to be congested and filled with watery fluid containing large numbers of spirilla. Unfortunately, however, other morphologically similar spirilla (the spirilla of Finkler-Prior, Deneke, and Miller) act very much in the same way, though somewhat less powerfully. Intraperitoneal injections of large quantities of cholera cultures also often produce death in rabbits and mice with similar symptoms.

With regard to the pathogenic properties of the cholera spirillum for man, there are quite a number of cases on record of accidental infection by pure cultures, which furnish the most satisfactory evidence of its being capable to produce the disease. In 1884 a student in Koch's laboratory in Berlin became ill with a severe attack of true Asiatic cholera while working with cholera cultures at a time when there was no cholera in Germany. In 1892 Pettenkofer and Emmerich experimented on themselves by swallowing small quantities of fresh cholera cultures, with the result that both of them were taken sick with typical cholera, one with mild and the other with severe symptoms. Since then other similar experiments have been reported, most of the persons taking the cultures having neutralized the acidity of the stomach previously by means of soda solution; and several fatal cases have occurred from accidental infection. At the same time, however, some negative results from experiments on the human subject have also been recorded—which only goes to show that in cholera, like other infectious diseases, an individual susceptibility is required, in addition to the presence of the germs, to produce infection.

According to Pfeiffer, cholera in man is an infective process due to the destruction of the epithelial layers of the intestines by the spirilla and the products of their growth, whereby intoxication results from absorption of the poisonous substances. The larger the surface of the mucous membrane affected, the more abundant will be the development of bacilli and the production of toxins, and the more pronounced, in consequence, will be the intoxication.

The cholera spirilla have recently been reported to have been frequently found in water (wells, water pipes, rivers, harbors, etc.) which has become contaminated with the evacuations of cholera patients. But to prove their presence beyond question in water is by no means easy, as there are so many other water bacteria simulating cholera bacilli from which they must be differentiated; hence some of the reported findings may not have been genuine cholera spirilla. The comma bacillus has been quite often observed in the fæces of healthy persons without producing, apparently, any pathogenic symptoms whatever. Abel and Claussen found thus cholera spirilla present in the stools, for days at a time, of fourteen out of seventeen healthy persons in the families of seven cholera patients. In Hamburg, during the last epidemic of cholera in Germany, twenty-eight such cases were observed in which the stools were absolutely normal.

The cholera spirillum, however, has been found in no other disease than true Asiatic cholera, occurring in this affection chiefly in the contents of the intestinal canal and especially in the mucous flakes of so-called "rice-water" stools, existing in pure culture frequently, and usually present in greatest numbers at the height of the attack. The spirilla are not, as a rule, found in the interior organs in recent cholera cases, except perhaps occasionally in the intestinal glands. In rare instances,

nevertheless, both in cholera patients and in inoculated animals, they have been met with in the organs—lungs, liver, kidneys, spleen, and occasionally the heart's blood. The more virulent the organism is, the more apt, apparently, is it to gain access to the interior organs.

Immunity.—Recovery from an attack of cholera produces a certain degree of immunity to the disease. Lazarus in 1892 observed that the blood serum of persons who had recently had cholera possessed the power of protecting guinea-pigs from infection by the cholera spirillum; while the serum of healthy persons or those affected with other diseases had no such effect. He attributed this to the presence, in the serum of convalescents from cholera, of antitoxic substances which neutralized the action of the toxins produced by the growth of the spirilla, in the same manner as the antitoxins of diphtheria and tetanus neutralize their respective toxins. Pfeiffer, on the other hand, maintained that this serum contained bactericidal substances which killed the spirilla so rapidly when injected into the animal that they were not able to produce their specific poisons, and that thus the animal was protected. It is now generally admitted that the serum is strongly bactericidal and feebly antitoxic.

These specific substances present in the blood of cholera-immune men and animals act only upon organisms similar to those with which they were originally infected—producing immobilization and agglutination of the bacilli. Pfeiffer, who first observed this peculiar reaction in cholera serum, has shown, however, that the specific relation existing between the antibacterial and protective substances produced during inmunization and the bacteria employed to immunize the animals is not confined alone to cholera. This discovery has given us an apparently reliable means of distinguishing the cholera and typhoid bacilli especially from all other similar organisms, and the diseases which they produce from other infections which may be mistaken for them, which has proved to be of great practical value as an aid to clinical diagnosis.

There are two methods, known as Pfeiffer's and Gruber's reactions, whereby genuine cholera spirilla may be differentiated from other similar vibrios:

1. *Pfeiffer's reaction* is produced as follows: The blood serum of an animal rendered immune to cholera, by inoculation of attenuated or dead cholera cultures, is mixed with ordinary bouillon in the proportion of 1 to 100, and in 1 c.c. of this mixture a platinum loopful (about 2 mgm.) of the species under investigation is added, and this then injected into the peritoneal cavity of a guinea-pig weighing about 200 gm. Every five minutes some of the peritoneal effusion is removed by means of a capillary pipette and examined microscopically both stained and unstained. If it is the true comma bacillus, the bacilli will be observed to become at first non-motile, then agglutinated into clumps, and finally (in about twenty minutes) to become disintegrated and loosened. When the above phenomena are absent, the organism belongs to another species. A control experiment should be made with a known cholera culture to avoid possible error.

2. *Gruber's reaction* is founded upon this, but he deserves the credit of having determined the amount of dilution required to agglutinate and immobilize the cholera spirilla when mixed with cholera-immune serum for microscopical examination in the hanging drop, without injection into guinea-pigs, thus simplifying the method for practical use. For this purpose the blood serum of a person suffering from a case of suspected cholera, or of an animal immunized against the species to be investigated, is mixed with a pure cholera culture in the proportion of 1 to 50 and upward, and the mixture at once examined in the hanging drop. If the spirilla become immobilized and agglutinated into clumps within twenty or thirty minutes, then they are genuine cholera spirilla; if not, the result is negative.

Within the last few years Haffkine in India has succeeded in producing an artificial immunity against cholera infection in man by means of subcutaneous injections of dead cultures of the cholera spirillum; and Kolle has found that the blood serum of persons thus inoculated gave a reaction similar to that of persons who had recovered from cholera, showing bactericidal and agglutinative substances from the fifth day, but most distinctly on the twentieth day and for months after the protective inoculation.

Spirilla Resembling the Spirillum Choleræ Asiaticæ.—When Koch's comma bacillus was first discovered its properties seemed so characteristic that it was considered an easy matter to distinguish it from all other bacteria. Since then, however, more and more similar organisms have been met with by various investigators, until now they have ceased to be designated even by special names. The following are among the best-known species:

Spirillum Finkler and Prior (*Vibrio Proteus*).—This organism was obtained by Finkler and Prior from the dejections of patients with cholera nostras which had been allowed to stand for some days. It has since been found to bear no etiological relation to the disease, and is only of interest on account of its resemblance in some respects to the cholera spirillum.

It occurs as more or less curved rods, usually somewhat longer and thicker than the cholera spirilla and not so uniform in diameter. Involution forms are common in unfavorable culture media. It is actively motile, a single flagellum being attached to one end of the rods. It does not form spores.

It grows equally well, in the presence and absence of oxygen, on the usual culture media at room temperature. On *gelatin plates* small, white, punctiform colonies are developed at the end of twenty-four hours, which under a low power are seen to be finely granular and yellowish in color; liquefaction of the gelatin around the colonies progresses rapidly and is usually complete in forty-eight hours. Isolated colonies on the second day form cup-shaped depressions. In *stab cultures on gelatin* liquefaction proceeds much more rapidly than with the cholera spirillum, a stocking-shaped pouch appearing in two days, while the entire gelatin is liquefied in about a week; a whitish film forms on the surface. Upon *agar* a moist, shining layer covering the entire surface is quickly developed. *Blood serum* is rapidly liquefied. On *potato* at room temperature a shining, grayish-yellow layer is formed, soon spreading over the surface. The cholera spirillum, on the other hand, produces no growth on potato at room temperature.

The cultures of the spirillum Finkler-Prior give off a strong putrefactive odor; in media containing sugar they produce acid; they do not form indol, and they have a greater resistance to desiccation than the cholera spirilla. The absence of the agglutinative reaction with a dilution of the serum of an animal immunized to cholera is a valuable differential sign.

This organism is pathogenic for guinea-pigs when introduced into the stomach after previous injection of soda solution and tincture of opium, similar symptoms being produced, only somewhat less marked, as with the cholera spirillum. Although originally observed in the dejections of persons affected with cholera nostras, it probably has no relation to this disease, having been seldom found since under such conditions by subsequent observers.

Miller's Spirillum.—In 1884 Miller observed a curved bacillus in dental caries which, from its microscopical appearances in cultures and from animal experiments, has been thought to be identical with the Finkler-Prior spirillum. The *vibrio heliogenes* of Fischer and the *vibrio Lisbonensis* of Pestana, and other similar spirilla met with from time to time, are also probably identical.

Deneke's Cheese Spirillum (*Vibrio Tyrogenes*).—This organism was obtained by Deneke from old cheese, but has since been rarely observed. Morphologically and culturally it shows greater resemblance to Koch's comma bacillus than does the Finkler and Prior spirillum. It occurs in curved rods and long spiral filaments, the

diameter of the segments being uniform throughout. On the other hand, it is somewhat more slender than the comma bacillus and the spiral turns are closer together. In its power of liquefying gelatin it stands between the cholera spirillum and the vibrio proteus, and its other characters are also so intermediary between these two species that they are scarce worth describing. It is said to form a thin, yellowish coating upon the surface of gelatin and agar stab cultures, and not to give the indol reaction; but these characteristics are not constant. The chief means of differentiating it from the cholera spirillum is by the serum reaction.

Spirillum Metschnikovi.—This spirillum was discovered by Gamaleïa in 1888 in the intestinal contents of fowls dying of an infectious disease common to certain parts of Southern Russia, and presenting symptoms like those of fowl cholera. It has since been found by Pfeiffer in the waters of the Spree and by Kutcher in those of the Lahn. In the affected animals it is almost always found in the intestines, but also in the blood, producing septicæmia. This interesting micro-organism cannot be morphologically distinguished from the cholera spirillum; it occurs as curved rods somewhat thicker, shorter, and often more decidedly bent than the comma bacillus. It liquefies gelatin, as a rule, much more rapidly than the cholera bacillus does, but this varies. It gives the nitroso-indol reaction without the addition of nitrites, and coagulates milk with acid reaction. It does not give the serum reaction with cholera-immune serum.

The spirillum Metschnikovi is characterized by its pathogenic action for chickens and pigeons; a minute quantity of a culture injected into the breast muscles of these animals causes their death with the local and general symptoms of fowl cholera, except that the contents of the intestines have more the appearance of cholera and the spleen is rather diminished than enlarged. In the blood and œdematous fluid about the necrotic point of inoculation, the organisms are present in large numbers. Gamaleïa has claimed that by passing the cholera spirillum of Koch through a series of pigeons, upon which this organism is said to act similarly to the vibrio Metschnikovi, by successive inoculations, its pathogenic power may be greatly increased, and that when sterilized cultures of this virulent variety of bacillus are injected into pigeons they become immune to the vibrio Metschnikovi, and *vice versa*. But Pfeiffer denies this—and the negative results obtained from the serum reaction with Metschnikoff's spirillum and cholera-immune serum show that the organisms are not identical.

The Spirillum of Relapsing Fever (*Spirochœte or Spirillum Obermeieri*).—First observed by Obermeier (1873) in the blood of a patient suffering from *febris recurrens*. Bacteriologically very little is known of this micro-organism. It occurs as long, slender, flexible, motile spirals or wavy filaments, with pointed ends, usually from 20 to 30 μ long. Flagella and spores have not been observed. Typically the organisms are found only in the blood and spleen, not in the secretions of patients with relapsing fever, and chiefly at the height of the disease, seldom or never during the intermissions. They stain readily with the ordinary aniline colors, especially with fuchsin and Loeffler's methylene blue solutions; they do not stain by Gram's method.

They have never been cultivated in artificial media. When preserved in blood serum and 0.5 per cent. solution of salt, they retain their vitality for a considerable time.

Inoculation experiments have been successfully made on man and monkeys. Monkeys when inoculated with human blood containing the spirilla take sick after about three and one-half days, but exhibit only the initial febrile attack; no relapse such as is characteristic of the disease in man occurs. Extirpation of the spleen renders the disease more dangerous for these animals. Infection may be transmitted by inoculation also from one monkey to another. Although so little is known of this organism from a bacteriological standpoint, the fact of its constant occurrence in relapsing fever and of the communicability of the disease from man to monkeys by inoculation of the blood gives us grounds for assuming that this is the cause of the affection.

The Glanders Bacillus (*Bacillus Mallei; Rotzbacillus; Bact. de la Morve*).—This bacillus was discovered by Loeffler and Schütz (1882) in the tissues of animals affected with glanders. It was isolated in pure culture by several bacteriologists, almost simultaneously, and was proved to be the cause of the disease with which it is associated.

Microscopical Appearances.—Small bacilli (2–3 μ long and 0.4 μ broad) with rounded or slightly pointed ends; they usually occur singly, but sometimes in pairs, and they rarely grow out to long filaments. Involution forms are common in old cultures. (See Plate XII., Fig. 4.)

Motility.—Non-motile.

Spore Formation.—Absent.

Staining Reactions.—Stains with difficulty with the ordinary aniline colors; does not stain by Gram's method. The bacilli often exhibit a granular appearance (metachromatic bodies) which are especially visible with Neisser's stain.

Biological Characters.—Aërobic and facultative anaërobic, growing both with and without oxygen, but best in the presence of oxygen and at brood temperature, though it develops slowly at 25° C.; does not grow at over 40° C. It may be cultivated on all the usual artificial media, but best on five-per-cent. glycerin agar.

On *glycerin agar* at the end of twenty-four to forty-eight hours it forms whitish, transparent colonies which in six or seven days may attain a diameter of 7 to 8 mm. On *blood serum* a moist, opaque, shiny layer of a yellowish or dirty-brown color is developed. The serum is not liquefied. On *potato* the growth is very characteristic. At the end of twenty-four to thirty-six hours at 37° C., a moist, yellow, transparent coating develops, becoming deeper in color and denser in consistence until it finally presents a reddish-brown color, and the surrounding surface of the potato acquires a greenish-yellow tint. The cultures often exhibit long, felt-like, interlaced filaments not unlike the threads of the bacillus anthracis, and finally club-like enlargements. In *bouillon* a diffuse clouding takes place, a tenacious, ropy sediment being ultimately formed. *Milk* is coagulated with the production of acid.

Vitality.—The resistance of cultures of the bacillus of glanders is not very great. They lose their virulence quickly by natural weakening as early as the fourth or fifth generation; therefore in order to retain virulence it is necessary after two or three generations of cultures to pass the virus through a susceptible animal. According to Bonome the glanders bacillus dies in ten days when exposed to a temperature of 25° C.; but other authorities find that it may live for three months under similar conditions. Exposed to heat the bacilli are killed at 80° C. in five minutes, and at 100° C. in three minutes.

Corrosive sublimate solution (1 to 1,000) destroys the bacilli in fifteen minutes, and five-per cent. carbolic acid in one hour. The virulence is quickly lost in distilled water (six days); it is not destroyed by putrefaction.

Pathogenesis.—Among domestic animals, horses, asses, cats, dogs, goats, sheep are the most susceptible; less so pigs. Cattle and birds are immune. Among test animals, the field mouse, wood mouse, and guinea-pig are the most susceptible, the rabbit being less so, while white mice and house mice are comparatively immune. When pure cultures of the bacillus mallei are injected into horses and other susceptible animals true glanders is produced. The disease in the horse is characterized by the formation of ulcers upon the nasal mucous membrane. These ulcers have irregular, thickened margins and secrete a thin, virulent mucus; the submaxillary glands become enlarged and form a tumor; other lymphatic glands also become inflamed, and some of them suppurate and open externally, leaving deep ulcers; the lungs are finally involved and the breathing becomes rapid and irregular. In farcy, which is a more chronic form of the disease, circumscribed swellings appear in different parts of the

body, especially where the skin is thinnest, which suppurate and leave angry-looking ulcers with abundant purulent disharge. Pure cultures can be obtained from the interior of the suppurating nodules and glands which have not yet opened to the surface; but the discharge from the nostrils or from an open ulcer contains comparatively few bacilli, and these are associated with so many other bacteria which grow more readily than the glanders bacilli on culture media that it is difficult to obtain pure cultures in this way by the plate method. Here test animals are useful.

In guinea-pigs subcutaneous injections are followed in three or four days by swelling at the point of inoculation, and a tumor with caseous contents soon develops, then ulceration of the skin takes place. The lymphatic glands become inflamed, and in from two to three weeks symptoms of general infection appear. In male animals orchitis and epididymitis are present, while the internal organs (lungs, kidneys, spleen, and liver) are generally the seat of characteristic nodular formations. From these pure cultures may be obtained. The specific ulcers produced upon the nasal mucous membranes of the horse are rarely present in guinea-pigs. The process is often prolonged, and the animals may live from six to eight weeks after inoculation; or it remains localized in the skin. Intraperitoneal injection of guinea-pigs is usually followed by death in from eight to ten days, and in males the testicles are invariably affected. In female animals the disease may be communicated to the fœtus.

The bacillus of glanders has never been found outside of the animal body nor in healthy individuals. The disease occurs as a natural infection only in horses and asses, but it may be communicated to man by contact with affected animals, and usually by inoculation through wounds of the skin or mucous membranes. In man, where the virus enters, a local swelling appears, which spreads rapidly, accompanied by suppuration and cording of the neighboring lymphatics. Multiple abscesses are formed in the skin, muscle, and internal organs, and there are often suppurative changes in the joints, the disease at this stage resembling pyæmia. Characteristic glanders nodules appear in the mucous membranes, particularly of the nose, which soon disintegrate, forming ulcers. The disease not infrequently terminates fatally, death resulting from general infection carried by means of the lymph circulation.

It is often difficult to demonstrate microscopically the presence of the glanders bacillus in the nodules which have undergone purulent degeneration, or in the discharge from the nostrils, ulcers and glands. Strauss has proposed the following rapid method of diagnosis by inoculation of test animals: Some of the suspected material or culture is introduced into the peritoneal cavity of a male guinea-pig, making the inoculation directly in the middle line of the abdomen, to avoid introduction into the vesiculæ seminalis. If it is a case of glanders, the testicles begin to swell within thirty to forty-eight hours, and the skin over them becomes hyperæmic, shiny, and finally degenerates and shows evidences of pus formation. The diagnostic symptom is the tumefaction of the testicles.

The diagnosis of glanders in horses, in which the clinical symptoms of the disease may be obscure, as in chronic or subacute cases, may often be made by the use of *mallein*. Mallein consists of the filtered products of the glanders bacillus—albuminous compounds bearing a similar relation to glanders that Koch's old tuberculin bears to tuberculosis—prepared by evaporating a six-weeks'-old culture in five per cent. glycerin nutrient veal broth to ten per cent. of its original bulk. The dose of mallein is about 1 c.c. subcutaneously injected, which usually gives good reactions. An injection of mallein under the skin of a healthy horse has no effect or at most produces a slight local swelling and rise of temperature. Following an injection of mallein into a glandered horse two reactions are produced: a large and painful swelling at the point of inoculation and a rise of temperature to 104 or even 106° F. The rise of temperature, however, should not be taken alone as conclusively indicating glanders; it must be considered in connection with the local swelling and the general condition of the animal which is profoundly affected by the injection. The practical value of this test has been demonstrated by numerous experiments by veterinarians. No ill effects have been found to result from the injection of mallein in healthy horses. On the contrary, not only production of immunity, but some cures have been reported from its use.

THE BACILLUS OF BUBONIC PLAGUE (*Bacillus Pestis Bubonicæ*).—This organism was discovered by Kitasato and Yersin, independently, during an epidemic of the bubonic plague at Hong-Kong, China, in 1894. This disease, like anthrax and leprosy, has a long historical record behind it. It is probably the disease which under the names of "Black Death" or "The Great Plague" decimated the population of Europe in the Middle Ages. The distribution of plague at the present time is fortunately a somewhat limited one, namely, a definite area in Asia known as the "Plague Belt," extending from Mesopotamia, as a sort of focus, northward to the Caspian Sea, westward to the Red Sea, southward as far as Central India, and eastward to the China Sea. The bacteriology of plague is almost the latest contribution to the science.

Microscopical Appearances.—Short rods, with rounded ends, about twice as long as broad, occurring singly, in pairs, or in short chains (especially in bouillon cultures), and often surrounded by a capsule. Involution forms are common. (See Plate XII., Figs. 7 and 8.)

Motility.—Non-motile, possessing no flagella; though Kitasato claims that it has very sluggish, scarcely perceptible movements, and Gordon states that by a special method of staining (Van Ermengen's method) he found polar flagella.

Spore Formation.—Absent.

Staining Reactions.—Stains with the ordinary aniline dyes, but in preparations made from pure cultures the characteristic bipolar staining, which is observed in preparations from blood and pus, is not readily obtained. Does not stain by Gram's method.

Biological Characters.—Strongly aërobic, growth being inhibited in the absence of oxygen. Develops on the usual culture media, but best on blood serum at 37° C.; also fairly well at room temperature.

On *gelatin plates* small, darkly defined granular colonies of a grayish-yellow to greenish color develop; the gelatin is not liquefied. In *gelatin stab cultures* it grows slowly on the surface and along the track of the needle. On *glycerin agar* it grows rapidly, forming a moist, grayish-white coating on the surface. On *blood serum* in the incubator, at the end of twenty-four to forty-eight hours, white, moist, transparent, and iridescent colonies are formed. *Bouillon* becomes diffusely clouded, but if inoculated with a cohesive mass of bacteria from an agar culture the bacilli develop as a granular or grumous deposit on the walls and bottom of the tube, the upper portion of the liquid remaining clear, similarly to what is observed in the growth of some varieties of streptococci. There is a scanty growth on *potato* and *milk;* milk is not coagulated.

The bacillus of bubonic plague forms no gas in media containing sugar, and but little indol. It produces toxins, and the serum of animals immunized against the bacillus yields antitoxic substances.

Vitality.—The bacilli of bubonic plague withstand desiccation for from three to seven days; in water they die in from three to eight days according to its composition; in buried cadavera they retain their vitality for twenty-eight to thirty-eight days. Exposed to the action of direct sunlight they are destroyed in from three to four hours. They are killed by heating at 55° C. in ten minutes, and at 80° C. in five minutes. Corrosive sublimate (1 to 1,000) destroys the bacilli immediately.

Pathogenesis.—This bacillus is pathogenic for almost all animals, only pigeons being immune. Guinea-pigs, rats, and mice are the most susceptible animals; somewhat less so are monkeys, rabbits, cats, and horses; and still less so are dogs and cattle. Guinea-pigs when in-

EXPLANATION OF
PLATE XII.

EXPLANATION OF PLATE XII.

FIG. 1.—Bacillus Anthracis from Cellular Tissue of Inoculated Mouse. Stained with gentian violet. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 2.—Anthrax Spores from a Bouillon Culture. Double-stained preparation—with carbol-fuchsin and methylene blue. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 3.—Bacillus of Tetanus from an Agar Culture. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 4.—Bacillus of Glanders. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

FIG. 5.—Spirillum of Asiatic Cholera (Comma Bacillus). From a culture upon starched linen at end of twenty-four hours, stained with fuchsin. × 1,000. Photomicrograph from Sternberg's "Bacteriology" by permission.

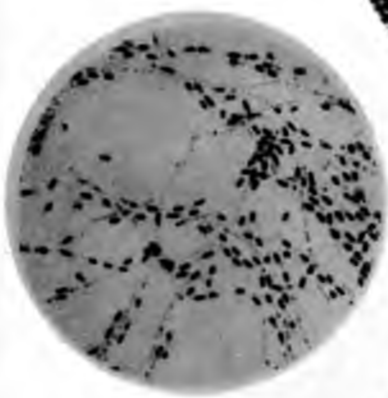
FIG. 6.—Spirillum of Finkler and Prior with Flagella. Agar culture. × 1,000. Photomicrograph from Bowhill's "Bacteriology" by permission.

FIG. 7.—Bacillus of Bubonic Plague from Agar Culture, Showing Irregular Forms. × 1,000. Photomicrograph.

FIG. 8.—Bacillus of Bubonic Plague from Bouillon Culture, Showing Rods in Chains with Polar Staining. × 1,000. Photomicrograph.

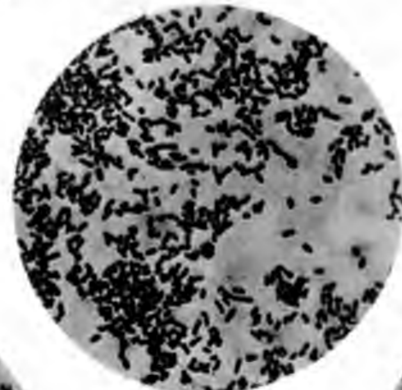
Plate XII.

I.
Bacillus Anthracis.



II.
Anthrax Bacillus,
with Spores.

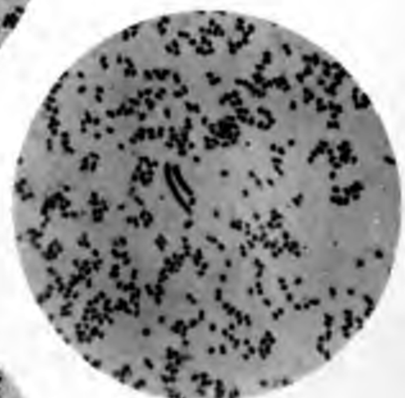
III.
Tetanus Bacillus.



IV.
Glanders Bacillus.

V.
Cholera Spirillum.

VI.
Spirillum Finkler-Prior.



VII.
Plague Bacillus.
(Agar Culture).

VIII.
Plague Bacillus.
(Broth Culture).

Pathogenic Bacteria.

jected intraperitoneally with pure cultures die in about two days of acute septicæmia, few bacteria being found in the tissues. At the point of inoculation there will be seen a hemorrhagic infiltration and œdema, with enlargements of the mesenteric glands and parenchymatous congestion of the organs. The spleen sometimes shows minute nodules resembling miliary tubercles, which contain zoöglœa-like masses of the bacilli. Guinea-pigs are also easily infected through the digestive tract. Flies, bedbugs, fleas, and other insects take up the organisms with the blood of plague-infected animals, but apparently they rarely transmit the disease. Infection, however, is rapidly communicated from one animal to another.

Hankin and Yersin have repeatedly found non-virulent plague bacilli in the dust of infected houses and in the soil. They have never been found in healthy individuals. Among animals the bubonic plague is known to occur spontaneously in rats, which often are affected previously to human epidemics. It is thought that these animals communicate the disease to man. In patients suffering from plague the bacilli are found chiefly in the pus of the characteristic buboes and also in the sputum from the pneumonic forms of the disease; more rarely in the internal organs and the blood.

This organism is the specific cause of true Oriental bubonic plague, the mortality from which is from fifty to eighty per cent. of cases. It gains access to the body (1) through the skin. Here the bacilli may remain localized and multiply at first in the neighboring lymph glands; frequently at the point of inoculation a pustule is formed which takes on the nature of a furuncle or carbuncle containing many bacilli. Death may occur without further diffusion of the organisms, but ordinarily they are distributed throughout the entire body, producing death by septicæmia. (2) Through the lungs. This constitutes the so-called pneumonic form, or plague pneumonia. The bacilli are present in the sputum and sometimes in the blood; other pus cocci are found in association. (3) Through the digestive tract. This mode of infection has been demonstrated in animals, but is uncertain in man.

Immunity.—Yersin, Calmette, and Borrel have succeeded in producing passive immunity against the plague bacillus in animals, and also to a certain extent in man, by subcutaneous inoculations with the serum of horses which were previously immunized by intravenous inoculation of dead cultures. Such serum possesses also some curative effect in men and animals suffering from the plague, if inoculated with large quantities and within twelve hours after infection. Roux maintains that this serum contains only antitoxic, not bactericidal, substances. Active immunity may also be produced, and apparently without danger, by Haffkine's method of preventive inoculation in the same manner as with cholera. This method consists in the subcutaneous injection of 2.5–3 c.c. of a fully grown bouillon culture heated for one hour at 70° C. to kill the organisms. The reaction caused (fever and pain) is usually slight, and the injection is best repeated after ten days. This treatment is essentially protective rather than curative, and although the immunity afforded is not absolute and lasts only for a month or two, the majority of those inoculated are protected or have the disease only in a mild form and recover.

The German Plague Commission considers puncture of the unopened bubo for diagnostic purposes somewhat dangerous, on account of possible infection of the blood; but the English physicians in India make a long incision in the affected gland, which is afterward dressed with antiseptics. In this way material is obtained for cover-glass specimens, plate and other cultural methods. The pus of the buboes, and especially the sputum in the pneumonic forms, contain numbers of bacilli. In these cases microscopical examination alone suffices often to make a probable diagnosis of the plague from the peculiar bipolar staining of the organisms. Microscopical examination of the blood is attended with success only in cases of general infection, and here cultures yield better results. It is recommended to make streak cultures on gelatin plates at 22° C., at which temperature the plague bacillus grows fairly well, while the streptococcus and other associated bacteria usually exhibit only scanty growth. According to Hankin, when the bacilli are grown on agar containing 2.5 to 3.5 per cent. of salt at 31° C., in twenty-four to forty-eight hours inoculation forms, consisting of pear-shaped bodies and spheres, are developed, which he considers characteristic enough to form a means of diagnosis. Finally, the serum of men and animals affected with the plague possesses the power of agglutinating the bacillus pestis. This reaction is said to be present in the second week, and is most pronounced in the second and third weeks of the disease.

The Streptothrices.

The varieties of the streptothrix group of micro-organisms have not as yet been clearly described. Some of them at least are pathogenic. These organisms, while having many points of resemblance to bacteria, yet differ from them in other important respects which connect them with the fungi. Like the mould fungi they develop from spore-like bodies into cylindrical dichotomously branching threads which grow into colonies, finally becoming visible to the naked eye as irregular radiating thread masses or mycelia. Under favorable conditions single threads or fruit hyphæ grow upward out of the substance, free in the air, and break up into chains of round, spore-like bodies or conidia, which being detached from the plant are carried by the air, and thus the preservation of the species is assured. The bacilli of tuberculosis, leprosy, diphtheria, and glanders are believed by some properly to belong to the streptothrices on account of the true branching forms developed by them under certain conditions. The best known of this group is the actinomyces or ray fungus.

Streptothrix Actinomyces.—This micro-organism was first described by Bollinger (1871) in cattle, in which it forms the affection known as "big jaw." In man actinomycosis was first recognized by Israel (1885), and subsequently Ponfick insisted upon the identity of the affection in man and cattle. So-called "madura-foot," an ulcerative disease of the feet, rarely of the hands, is by some also thought to be another form of infection caused by this organism.

Microscopical Appearances.—In both man and animals the organism can be observed in the pus from the affected regions as small, yellowish granules from 0.5 to 2 μ in diameter. Microscopically these bodies are seen to be made up of threads which radiate from a centre and present bulbous, club-like terminations. These are generally arranged in pairs, closely crowded together, and exhibit a glistening appearance. The threads which compose the central masses are from 0.3 to 0.5 μ in diameter; the clubs are from 6 to 8 μ in diameter, and are either single or branching.

Staining Reactions.—The thread fungi, not the clubs, stain best by Gram's method. Double staining can be obtained with the Gram method and then with picro-carmine or saffronin, the thread being stained a blue-black color by Gram's solution, while the clubs are stained red.

Biological Characters.—Aërobic and facultative anaërobic, growing on all artificial culture media at room temperature, but best with access of air and at the temperature of the body.

On *blood serum* and *agar* isolated colonies at first develop on the surface of these media, but on keeping the cultures for a week or two the colonies run together and form a thick, wrinkled mass which sinks into the medium. The individual colonies are yellowish to red in color, and are covered by a whitish fluffy down, consisting of fine cobweb-like hairs; occasionally the culture is colored brown. In *stab cultures* the growth usually presents a tree-like appearance, but this varies considerably. *Bouillon* is not clouded, but round masses are formed in the bottom of the tube, which are separated with difficulty by shaking. On *potato* the growth is somewhat

slower, resulting in a thick, viscid, membranous deposit on the surface, upon which the same yellowish-red color and cobweb-like thread are developed. On *eggs*, either raw or cooked, Wolff and Israel have cultivated especially well-developed branching forms.

Vitality.—The cultures are quite resistant to outside influences, old cultures retaining their vitality for months. Dried they may be kept for a year or more. They are killed by a temperature of 75° C. in five minutes.

Pathogenesis.—The actinomyces have never been found outside the animal body, but they probably occur in the husks and straw of grains and grasses, as the usual mode of acquiring the disease is apparently through the introduction of these materials, which have been met with in the centres of actinomycotic infection. They have never been found in healthy animals. The chief modes of infection in man are through the mouth and mucous membranes of the throat, through the air passages, through the intestinal canal, and through the skin. From the primary centres of infection the fungus is conveyed by wandering cells and emboli to all parts of the body, giving rise to soft granulation tissue which has a tendency to break down, and contains, in addition to small round cells, epithelial elements and giant cells, not unlike those found in tubercles. The formation of fistulæ which undermine the skin favors the passage of the organism through muscular tissues and furthers the spread of the disease. More rarely, circumscribed tumors, as seen in cattle, also occur in man. The fungi are found in the pus of the affected parts, there being scarcely an organ or tissue of the body free from actinomyces.

Among animals cattle are especially subject to the disease; more rarely, pigs, dogs, and horses. The most common seat of infection is in the interior of the bone of the jaw, with the formation of granulation tissue and of new bone from the periosteum. In other cases the soft parts of the face are primarily attacked and the bone affected from the outside. The walls of the throat and stomach are sometimes first infected. The affection of the jaw gives to the disease its name of "big jaw"; it was formerly mistaken for osteosarcoma and other similar affections.

The experimental production of actinomycosis in animals has not been satisfactory. When artificially introduced into the tissues the organism becomes absorbed or encapsulated. If injected in large quantities multiple nodules are formed in some cases, and these suggest the production of a general infection, but no growth of the organisms really takes place. Ponfick, Johne, Rotter, and others claim to have obtained positive results in animals, but Boström does not consider these conclusive. The animals used for experimentation have been calves, pigs, dogs, rabbits, and guinea-pigs; the points of inoculation, the anterior chamber of the eye, the subcutaneous tissue, the peritoneal cavity, and the blood-vessels; and the material injected, pus from the affected parts, very rarely cultures.

A number of other streptothrices have been described in connection with various pathogenic processes, but most of them are not well defined. They have been found in abscess of the brain, cerebro-spinal meningitis, inflamed pneumonic areas, and other pathological conditions. Eppinger injected cultures of a streptothrix found by him in brain abscess into rabbits and guinea-pigs, and from this a pseudo-tuberculosis developed. Consolidation of portions of both lungs, thickening of the peritoneum, and scattered nodules closely resembling tubercles were also noted by Flexner in a case of human infection from a variety of streptothrix, the pathological conditions so nearly resembling tuberculosis that the two diseases could be distinguished only by the morphological and other characteristics of the causative micro-organisms in each case.

The Hyphomycetes or Mould Fungi.

Most of the mould fungi are not pathogenic and are of interest to us only as organisms which are apt to contaminate our bacteriological media. Some of them, however, are true parasites, among which the best known are the *achorion Schönleinii*, *trichophyton*, *oïdium albicans*, and *microsporon furfur*. These can be only briefly touched upon in this article, as they are not bacteria, and yet some reference to them would seem to be called for here.

Achorion Schönleinii (*Favus Fungus*).—This fungus, which is the cause of favus in man and animals (horses, cattle, dogs, cats, rabbits, mice), was discovered by Schönlein in 1839. The disease is communicated to man by contact with animals. Want of cleanliness is a contributing factor. The fungus seems to find a more favorable soil for its development on the skin of persons in a debilitated condition, especially from phthisis, than in healthy individuals.

Pathologically the disease represents the reaction of the tissues to the irritation caused by the growth of the fungus, the spores finding their way into the hair follicles, where they develop around the hair seat. The achorion grows in the epidermis, the density of the growth causing pressure on the parts below, thus crushing out the vitality of the hair and giving rise to atrophic scarring. This disease shows a marked preference for the scalp possessing hair but it is also found on skin devoid of hair, and even the mucous membranes or the nails may be attacked. Kaposi describes a case of favus universalis. On the scalp it first appears as a tiny sulphur-yellow disc or *scutum*, depressed in the centre like a cup and pierced by a hair. This is the characteristic lesion. The cup shape is attributed by Unna to growth at the sides proceeding more vigorously than at the centre.

According to Unna, Quincke, and others there are several varieties of favus fungi, but later investigations would seem to indicate that the achorion Schönleinii is the only species of fungus producing favus.

As seen under the microscope the mycelium consists of branched radiating hyphæ. Some of the hyphæ swell at their free ends, becoming club-shaped, while others give off lateral buds containing Kral's so-called "yellow bodies," which rupture, allowing their contents to escape as free bodies. When this takes place, moss-like offshoots develop in the form of dense, twisted threads. Later, the individual threads break up into cell-like, oval structures.

The favus fungus is readily cultivated at both room and body temperatures on the ordinary nutrient media. The growth develops slowly and shows a preference to grow beneath the surface of the medium. The characteristic form of growth is that of moss-like projections from a central body, the color being at first grayish white and then becoming yellow. To obtain the fungus in pure cultures the "favus crusts" are mixed with sterile silicic acid, reduced in a sterile mortar, and plate cultures on gelatin or agar are made from this mixture. Blood serum is the only medium on which the spores are developed, the most favorable temperature being 30° C. Artificial infection can be produced only with material containing spores.

Trichophyton (*Ringworm Fungus*).—Ringworm of the body or hairless parts (tinea circinata), and ringworm of the hairy parts (tinea tonsurans and tinea barbæ or sycosis) are due to the fungus trichophyton, discovered by Gruby in the human hair, and between the epidermal cells by Hebra.

According Sabouraud (whose conclusions are based on an exhaustive series of microscopical examinations of cases of tinea in man and animals, of cultivation of artificial media, and of inoculation experiments), there are two distinct types of the fungus trichophyton, causing ringworm in man; they are distinguished by the size of their spores—one with small spores 2 to 3 μ in diameter, which he calls Trichophyton microsporon, and another with large spores, 7 to 8 μ in diameter, which he calls Trichophyton megalosporon. These differ both in their mode of growth on artificial media and in their pathological effects on the human skin and its appendages.

Trichophyton microsporon is the common fungus of tinea tonsurans in children, more particularly the severe affection known as the "Maladie de Gruby," which is re-

bellious under treatment, and its special seat of growth is the substance of the hair. Trichophyton megalosporon is essentially the fungus of ringworm of the beard and of the smooth parts of the skin in adults.

Under the microscope the single mycelial threads are distinctly separate and from them conidia are given off. The spores of T. microsporon are contained in a mycelium; but this is not visible, the spores appearing irregularly piled up like zoöglœa masses; and growing outside, they form a dense sheath around the hair. The spores of T. megalosporon are always contained in distinct mycelium filaments, which may be either resistant when the hair is broken up, or fragile and easily separating into spores.

The trichophyton grows at room temperature, but best at 30° C. on the usual media. It liquefies gelatin, agar, and blood serum. The two types when grown on artificial cultures also show a downy surface and white color; those of T. megalosporon a powdery surface, with arborescent peripheral rays, and often a yellowish color.

Although the morphological appearances, mode of growth, and pathological effects of each type of trichophyton show certain characters in common, yet there are some constant minor differences which point to the fact that there are several varieties or species of fungi included under each type. The species included under T. microsporon are few in number, and with one exception (that which causes the contagious herpes of the horse) almost entirely human. The species of T. megalosporon are numerous, and many animals as well as man are subject to affections caused by the various species.

In contradistinction to other fungi, the cultures of trichophyton retain their vitality for a long time. The disease has been produced articially in animals by inoculation with material containing spores.

OIDIUM ALBICANS (*Thrush Fungus*).—This fungus, which was discovered by Bery and fully described by Gruby, is the cause of thrush, and occurs in all mucous membranes with squamous epithelium, especially in the mouths of infants, where it is manifested by white points or patches on the inflamed surface. The usual seat of thrush is the buccal membrane of children, but occasionally it occurs in the faucial and œsophageal surfaces; rarely in the middle ear, trachea, and subdiaphragmatic portion of the digestive tract.

Under the microscope this parasite is seen to consist of mycelial threads; numerous spherical or ovoid spaces or conidia are also present surrounding the mycelium and covering the epithelial cells.

The oïdium albicans is strongly aërobic, growing on all the usual culture media in the presence of oxygen, best at 37° C. It does not liquefy gelatin, upon this medium forming white colonies. On agar a yellowish-white growth is developed.

It is pathogenic for rabbits when inoculated intravenously, the fungus becoming localized in the internal organs.

Haller considers that this organism is identical with, or very closely allied to, the *oïdium lactis*, which occurs in milk undergoing acid fermentation.

MICROSPORON FURFUR (*Pityriasis Fungus*).—This fungus is the cause of tinea or pityriasis versicolor, and is found in the scales cast off by the skin in this affection. When these scales are treated with a five-per-cent. solution of caustic potash and examined microscopically, short, slightly branched mycelial threads are seen with very large conidia lying together in clusters. The fungus has not been cultivated artificially, but tinea versicolor has been produced by experimental inoculation, both in men and animals.

THE BLASTOMYCETES OR YEAST FUNGI.

The yeast fungi are divided into two groups: (1) *Saccharomycetes* or true yeasts, in which true spore formation occurs; (2) *torulæ*, in which no spore formation has been observed.

The blastomycetes reproduce themselves by germination or budding, which distinguishes them from the schizomycetes or bacteria which reproduce themselves by fission or division. From the hyphomycetes or mould fungi they are distinguished by being unicellular and by a sexual reproduction. They are round or oval cells, usually many times larger than bacteria.

These organisms are of the greatest practical importance in various commercial industries, such as brewing, baking, etc., but as yet very little is known of their pathogenic properties in man. Certain varieties, when injected into animals, have proved to be pathogenic and capable of producing tumors, and recently they have apparently been demonstrated (by Sanfelice, Plimmer, and others) in the epithelial cells in cases of cancer in the human subject; but what relation they bear, if any, to this affection is yet to be determined. They are not infrequently present in the air and in cultures made from the healthy throat.

Memmo has also stated that in some cases of hydrophobia he found a blastomycete possessing pathogenic properties which he considers to be the cause of the infection. The fungus was found in the cerebro-spinal fluid, the substance of the brain, aqueous humor, stroma of the parotid gland, and in the saliva, but never in the heart's blood or in other organs. Dogs injected with cultures of this micro-organism began, in from thirty to sixty days, to emaciate, became rabid, vomited, and finally died. Paralysis of the extremities immediately preceded death. The fungus was also found in sections of the spinal cord of a dog dead of rabies.

Judging from these experiments, which, however, require confirmation, the yeast fungi may eventually prove to be of considerable pathogenic importance.

THE PROTOZOA OR ANIMAL PARASITES.

The protozoa are the lowest forms of animal life, embracing organisms consisting of a single cell or groups of cells not separable into different tissues. They reproduce usually by fission, germination, or spore formation. The protozoa are divided into: (1) *Gymnomyxa* (including proteromorpha, mycetozoa, lobosa, labarinthulidea, heliozoa, radiolaria, and foraminifera); (2) *corticata* (including infusoria and sporozoa).

To this family of animal parasites belong the amœba coli, the plasmodium malariæ, and the pyrosoma bigemium,—the specific cause, respectively, of tropic dysentery, malarial fever, and Texas cattle fever. These organisms will be described elsewhere, so that we only refer to them here in order to complete the list of interesting pathogenic micro-organisms.

Arthur R. Guerard.

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BACTERIAL TECHNIQUE. See *Micro-Organisms: Technology.*

BAEL FRUIT.—The fruit of *Aegle Marmelos* Correo (fam. *Rutaceæ*). The bael is a sacred tree among the Hindus, and its use in medicine pertains largely to religion and mythology. It is a near relative of the orange, to which it bears a general resemblance in tree, flower, and fruit. The fruit, of the size, shape, and structure of an orange and with a somewhat similar pulp, differs in having a hard smooth shell, the pulp mucilaginous, and the seeds enclosed in a woolly covering. For medicinal purposes it is collected and dried in slices, usually in quarters, with the shell retained. In the dried condition the pulp is dry, hard, and gummy, and of a mucilaginous, slightly acid, and somewhat bitter taste. Although it contains no tannin, or any other constituent which might be expected to be medicinal, it has been recommended in diarrhœa and dysentery. Possibly the large amount of mucilage which it yields may act as a demulcent. There is no fixed dose. *H. H. Rusby.*

BAELZ'S DISEASE OF THE LIP is a local infection of the mucous membrane of the lips characterized by an indolent swelling and infiltration of the tissues about the mucous glands and a slow ulceration from above downward. It is a chronic disease, and ceases only with the destruction of the affected gland. It is frequently accompanied by a superficial catarrhal inflammation of the mucous membrane of the lips. It has no relation to syphilis, tuberculosis, or cancer. It is a rare affection.

TREATMENT.—Apply tincture of iodine at first every other day, later daily. By this means a cure is readily effected. *G. T. J.*

BAHAMAS.—For an account of the climate, climatotherapy, etc., of the Bahama Islands, see the article on *Nassau*.

BAILEY SPRINGS.—Lauderdale County, Alabama.

POST-OFFICE.—Bailey Springs. Hotel.

ACCESS.—Via the Louisville and Nashville, and the Birmingham and Sheffield railroads; also by all steamboats on the Tennessee River. Tickets should be taken to Florence, Ala., nine miles distant by carriage or stage. This is one of the old-time Southern health resorts, the springs having been in use for upward of fifty years. They are located in a picturesque valley surrounded by a semicircular range of hills, among which will be found many leafy arcades and rocky nooks. A moss-banked stream a short distance from the springs, known as Shoal Creek, supplies visitors with facilities for boating and fishing. The hotel buildings are comfortable, old-fashioned structures situated on the summit of the hill, about three hundred feet above the level of Shoal Creek. They were overhauled and brought up to modern requirements a few years ago. The springs here are seven in number, known as the "Rock," "Brick," "Sulphur," "Freestone," "Soda," "Alum," and "Sour Iron" springs. The following qualitative analysis of the first three springs is taken from the author's recent work on "The Mineral Waters of the United States." It was supplied by Dr. W. A. Moody, of Florence, Ala., and is said to have been made under the direction of the Boston *Journal of Chemistry*.

Rock Spring.	*Brick Spring.*	*Sulphur Spring.*
Magnesium.	Carbonic acid.	Magnesium.
Calcium.	Sulphureted hydrogen gas.	Calcium.
Sodium.	Sodium carbonate.	Sulphur peroxide.
Chlorine.	Magnesium carbonate.	Chlorine.
Chlorine peroxide.	Potassium carbonate.	Iron.
Silica.	Sodium chloride.	Silica.
Potassium.	Iron oxide.	Sodium.
Carbonic acid.		Carbonic acid.
Ammonia, a trace.		Ammonia.

We cannot with certainty classify the waters from this analysis, although the "Rock" spring would appear to be an alkaline and the "Brick" and "Sulphur" springs alkaline chalybeates.

The waters are recommended for renal disease attended by dropsy, for dyspepsia, and for anæmia and general debility. They are believed to possess sedative effects upon the nervous system, and in virtue of this action are prescribed in cases of restlessness and insomnia due to alcoholism, overwork, anxiety, etc.

The "Alum" spring has acquired considerable reputation in the local treatment of skin affections, ulcerations, and inflammatory affections of the eye.

James K. Crook.

BALANITES ROXBURGHII (Planch).—(Fam. *Simarubaceæ.*) The bark and fruit of this small tree are ancient drugs of India, where they are used as purgatives and anthelmintics, both for human beings and for cattle. The active principle, or the chief one, appears to be saponin. Oil of Balanites is obtained from the kernels, and is said to be similar to peanut oil.

H. H. Rusby.

BALANITIS AND BALANO-POSTHITIS.—(βάλανος, an acorn; πόσθη, the foreskin.) An inflammation of the mucous membrane covering the glans penis (balanitis) and of that lining the prepuce (posthitis). This is a purely local affection which occurs very commonly as a complication of the various venereal diseases and, much more rarely, with diabetes mellitus. It has, however, no necessary relation with either, and results more often from other and simpler forms of irritation.

ETIOLOGY.—The anatomy of the part is the predisposing cause for this inflammation, the apposing surfaces of the mucous membrane favoring the retention of urine, smegma, or various pathological discharges until they may decompose and serve as irritants for the delicate mucous surfaces. If a prepuce is redundant and phimotic the opportunities for such retention of irritating substances are so much the greater.

Diabetes, rheumatism, and gout also predispose to this disease.

The immediate cause of the inflammation may be the mechanical irritation of friction (chafing of clothing, etc.) or the irritating discharges of syphilitic and chancroidal lesions, and urethral discharges, gonorrhœal or non-gonorrhœal. Vaginal and uterine discharges introduced under the prepuce during coitus may also serve as the exciting cause of the inflammation. By far the commonest cause, however, is uncleanliness and the consequent decomposition of urine and smegma with resulting irritation, and Fournier says that two-thirds of all cases are caused in this way by simple lack of cleanliness, while the other third is caused by the irritation of venereal discharges.

SYMPTOMS.—In the common and mild type of this inflammation a sensation of heat and itching is usually the first suggestion of trouble. Examination reveals a reddened and swollen membrane and the beginnings of an offensive discharge of a thick creamy character. The intensity of the process is usually greatest in the sulcus back of the corona glandis, as it is there that the discharge has the best opportunity to accumulate. If the disease progresses a stage further, the next result is a series of small excoriations which, together with a more profuse discharge and a much greater swelling of the prepuce (which in its turn results in a more or less complete inflammatory phimosis), completes the picture of the severe type of the disease which often occurs as a complication of syphilis, chancroid, and gonorrhœa. Even in these cases the complication is not the result of the activity of the specific germs of these diseases, but is a consequence of the irritating character of their discharges, or of an infection with pus-producing germs contained in them.

The erosions sometimes extend and involve most of the mucous membrane of both glans and prepuce, in which case they are apt to develop a circinate margin which is quite characteristic.

COMPLICATIONS.—Occasionally the process becomes so severe that *gangrene* results unless interference be prompt and effectual. The sloughing process may result in a more or less complete destruction of the prepuce and the formation of considerable cicatricial tissue. Occasionally the glans penis is found protruding through an opening which has sloughed through the prepuce. Such extreme destruction of tissue takes place naturally only in phimotic cases in which operative interference is impossible or is neglected.

An *hypertrophy* of the tissues of both prepuce and glans penis, similar to that seen at times as a result of the long-continued irritation of a rubber urinal, may result in persons who are subject to repeated attacks of balanitis. This hypertrophy is said to occur more commonly in the balanitis which accompanies diabetes mellitus, and the thick, rigid prepuce is often a great mechanical annoyance. It may, finally, assume an epitheliomatous character.

Condylomata frequently develop, most frequently in the post-coronal sulcus, in cases of recurrent balanitis.

Lymphadenitis occurs, but rarely results in suppurating bubo.

Paraphimosis of the thickened and inflamed prepuce is not an uncommon complication.

DIAGNOSIS.—The diagnosis is usually easy except in cases in which inflammatory phimosis exists and a purulent discharge with non-retractile prepuce is present. In such cases a distinct, localized area of induration felt through the swollen prepuce suggests the initial lesion of syphilis, and continued search generally reveals other indications of that disease. Gonococci in the pus establish the gonorrhœal origin of the process, while the extent of the inflammation together with its rapid progress and the frequent presence of chancroidal ulcers on the preputial margin will usually serve to indicate the chancroidal origin of the disease. If the prepuce is retractile and the lesions can be seen and examined, the diagnosis is usually simple. The history of the case and the appearance of other lesions usually make the syphilitic origin of the inflammation plain, while the markedly circumscribed character of the erosions (which quickly become typical chancroidal ulcers), together with the greater inflammatory hardness and thickening of the tissues of the glans and prepuce, usually leave no doubt as to the chancroidal character of the process. Erosions due to herpes cannot always be distinguished from those of balanitis, although in most cases some few small, discrete, herpetic vesicles will prove characteristic enough to make the diagnosis clear.

PROGNOSIS.—The prognosis is good, but one should not forget the possibility of the gangrene, which occurs rarely in old and debilitated persons or in those cases in which proper treatment is neglected or is impossible.

TREATMENT.—The prophylaxis of this inflammation consists in cleanliness. Retraction of the prepuce and daily washing of the subpreputial cavity usually suffice to prevent a recurrence of the trouble.

Treatment of the ordinary type of the inflammation should be carried out about as follows: (1) retraction of the prepuce; (2) a mild antiseptic wash, *e.g.*, dilute lead wash or 1 to 5,000 corrosive sublimate; (3) careful drying of the exposed surfaces in such a manner as not to chafe and irritate them; (4) dusting on an unirritating powder such as bismuth, bismuth and calomel in equal parts, aristol (in the chancroidal cases), oxalate of cerium; (5) separating the powdered surfaces of membrane by a very thin layer of absorbent cotton.

If the discharge is profuse and the erosions are extensive it is often of advantage to omit the powder and to substitute a thin layer of absorbent cotton wrapped about the glans penis and then moistened with lead wash or some equally unirritating lotion. Erosions or ulcerations which do not heal readily should be gently touched with a bit of cotton on a cotton carrier slightly moistened with a solution of nitrate of silver—five to twenty per cent. as needed in individual cases.

Phimotic cases are often very troublesome, as their proper cleansing is wellnigh impossible of attainment. They should be irrigated very often, in severe cases every hour or two, with warm water followed by mild antiseptic solutions, a large urethral syringe with a blunt nozzle being as convenient an instrument as any for the purpose. Corrosive sublimate solution, 1 to 5,000, carbolic acid solution, 1 to 100, lysol, and creolin are all good irrigating fluids, but the writer does not approve of the use of peroxide of hydrogen in these cases, as it is very irritating and often causes much preputial swelling if used in strength sufficient to make it of much value.

If the disease proves stubborn and there is a probability that the ulcerative process is extending under the tight and swollen foreskin, every effort should be made to reduce the acuteness of the inflammation with hot soakings, etc., and then an operation under the strictest aseptic and antiseptic precautions should be performed, the patient being told that he is not to expect a primary healing. In such cases the dorsal incision of the prepuce may prove adequate to the needs of the case, but more frequently a complete circumcision is necessary. Even in the chancroidal cases the writer has never met with any untoward result from such operative procedures, although primary healing is by no means the rule.

In all cases, however mild, care should be taken in urinating to retract the foreskin sufficiently to lay bare the region of the meatus if possible, so that the urine may pass clear of the prepuce and not contaminate the subpreputial cotton, and so render its very frequent renewal more than ever imperative.

Cleanliness, then, with mild but constantly repeated antiseptic washes, and the dorsal incision or circumcision when needed in severe cases, form the basis of all treatment.

Paul Thorndike.

BALATA.—*Balata Gum.* A caoutchouc-like substance, intermediate in properties between india rubber and gutta percha, which is the concrete milky juice of at least two species of *Mimusops*, *M. Balata* Gaertn. and *M. Schomburgkii* (Pierre) (*M. Balata Schomburgkii* Pierre). This substance is not to be mistaken for *gum chicle*, of which chewing-gum is made, the product of *Achras Sapota* and other trees. The balatas are very large trees of Guiana and adjacent Venezuela, where they are popularly known as "bullet tree" or "bully tree." They frequently become four to six feet in diameter, and the wood is strong and valuable. The fruit is globular, mostly a little less than an inch in diameter, the space between the large seeds and the crustaceous exocarp being filled with an edible, rich and sugary pulp. As the writer has seen the gum collected upon the lower Orinoco, the trees are felled and girdled with grooves about ten inches apart. These grooves are cut through the bark to, or a little into, the wood, and conduct the exuding juice to the lower side of the trunk, where it is caught by small cups. Various methods are resorted to for its coagulation. The favorite one is to mix it with alcohol, or strong native rum, the coagulum then being pressed into cakes. Operations are now being conducted for extracting it from the bark, twigs, and leaves by the use of solvents. Up to the present, no distinct uses in medicine have been found for this substance, but it has many uses in the arts.

H. H. Rusby.

BALLARDVILLE LITHIA SPRING.—Middlesex County, Massachusetts. The location of this spring has not, we believe, been improved as a resort. It is situated on the side of a high hill, in a barren, rocky tract of country, with no dwelling within a mile. Land to the extent of fifty acres belonging to the Ballardville Lithia Company surrounds the spring. The water is beautifully clear and very pleasing to the palate, especially when charged with gas. It is said that the rocky deposits in the neighborhood contain a large proportion of such lithia-bearing minerals as spodumene and lepidolite. It is to this fact, we are informed, that the water owes its remarkable richness in this salt, as shown by the following analysis made by Dr. Bennett F. Davenport:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Lithium carbonate	22.01
Calcium carbonate	0.82
Iron oxide	0.70
Calcium chloride	0.52
Silica	0.46
Total	24.51

The water is said to be valuable in the various conditions produced by the retention of uric acid in the system, notably gout, concretions in the joints, kidneys, and bladder, and in certain forms of rheumatism. It is also useful in gouty affections of the skin, bronchial tubes, and kidneys. It is bottled and used commercially.

James K. Crook.

BALLSTON SPA.—Saratoga County, New York.

POST-OFFICE.—Ballston. Hotels.

ACCESS.—From Albany viâ Delaware and Hudson Railroad, thirty miles north. The location is seven miles southeast of Saratoga Springs.

The fame of Ballston Springs is almost coeval with that of Saratoga, and at one time it was a formidable rival of that celebrated resort. Ballston is a very attractive town, where those who wish to avoid the whirl of Saratoga may live quietly and drink excellent mineral waters at the same time. Some of the springs are very heavily mineralized. Following are analyses of four of the most important:—

ONE UNITED STATES GALLON CONTAINS:

Solids.	Sans Souci Spring. J. H. Steele. Grains.	Artesian Lithia Spring. C. F. Chandler. Grains.	Franklin Artesian Well. C. F. Chandler. Grains.	United States. L. C. Beck. Grains.
Sodium carbonate	12.66	....	....	16.88
Sodium bicarbonate	....	11.93	94.60	
Calcium carbonate (with iron oxide)	43.41	....	....	29.20
Calcium bicarbonate	....	238.16	202.33	
Magnesium carbonate	....	...	....	5.76
Magnesium bicarbonate	39.10	180.60	177.87	
Strontium bicarbonate	....	0.87	Trace.	
Lithium bicarbonate	....	7.75	6.78	
Iron carbonate	5.95			
Iron bicarbonate	....	1.58	1.61	
Barium bicarbonate	....	3.88	1.23	
Sodium sulphate	....	...	....	1.76
Potassium sulphate	....	0.52	0.76	
Sodium phosphate	....	0.05	0.01	
Sodium biborate	....	Trace.	Trace.	
Sodium chloride	....	750.03	659.34	424.96
Potassium chloride	....	33.28	33.93	
Sodium bromide	143.73	3.64	4.67	
Calcium fluoride	....	Trace.	Trace.	
Sodium iodide	1.30	0.12	0.24	
Alumina	....	0.08	0.26	
Silica	1.00	0.76	0.74	8.00
Organic matter		Trace.	Trace.	
Total	247.15	1,233.25	1,184.37	486.56
Gas.	Cubic Inches.	Cubic Inches.	Cubic Inches.	Cubic Inches.
Carbonic acid	....	4,261.14	460.06	244.00

It will thus be observed that these waters are quite similar to those of Saratoga. Some of them are indeed much richer in mineral ingredients than any of the Saratoga waters. They are all saline, but some of them, as will be seen, are quite heavily impregnated with calcium, iron, and magnesium. The waters are certainly of great value for medicinal purposes. There are several other well-known springs at Ballston, among them being the Washington Lithia Well and the Iron Spring.

James K. Crook.

BALM.—This name, as well as various compounds of it, has been applied to so many different plants that its use is altogether indefinite. Only four of these drugs are of any degree of importance, and their descriptions should be sought as follows: For Lemon Balm, to which the term balm is most appropriately applied, see the next; for Bee Balm, see *Monarda;* for Patchouli Balm, see *Patchouli;* for Mountain Balm, see *Yerba Santa.*

H. H. Rusby.

BALM, LEMON. MELISSA.—"The leaves and tops of *Melissa officinalis* L. (fam. *Labiatæ*)" (U. S. P.). This is a perennial herb, from one-half to one metre in height (twenty to forty inches), with several branching, leafy stems. The branches are quadrangular, the leaves opposite, petiolate, about 5 cm. long, ovate, obtuse, rounded or subcordate at the base, crenate, somewhat hairy, glandular; flowers in about four-flowered cymules, with a tubular, bell-shaped, five-toothed calyx, a whitish or purplish bilabiate corolla, and four stamens; fragrant; somewhat astringent and bitterish.

The plant is a native of Southern Europe, and is frequently cultivated in Europe for the sake of its oil. It is now and then met with in American gardens.

The botanical description, given above, will serve for that of the drug, which, it may be remarked, loses very much of its fragrance in drying. Its principal constituent is the agreeable oil of balm, *Oleum Melissæ* (not to be confounded with the East Indian oil of citronella, which resembles it), of which it contains a small percentage (one-eighth to one-fourth per cent.).

FIG. 453.—Balm. Plant in flower reduced and flower enlarged. (Crié.)

Melissa has, in sufficient doses, the stimulant properties of the order, but as usually used is scarcely more than a flavor. An infusion of the herb can be given *ad libitum*, and when taken hot and in large quantity, like other mints, with the aid of hot water and plenty of coverings, is sudorific. The dose of the oil is ♏iss. ad ♏v.

W. P. Bolles.

BALM OF GILEAD.—A resinous exudation or so-called balsam, from the *Balsamodendron Gileadense* Kunth (fam. *Burseraceæ*), a small tree of the Red Sea region. It has ordinary aromatic stimulant properties. It is no longer in use, but possesses considerable historical interest. The name has also been applied to our northern balsam fir and its products (see *Canada Balsam*), as well as to the buds of Populus candicans Aiton.

H. H. Rusby.

BALSAMUM PERUVIANUM.—*Balsam of Peru.* "A balsam obtained from *Toluifera Pereiræ* (Royle) Baillon (fam. *Leguminosæ*)" (U. S. P.). This is a good-sized tree, with a dark, smooth trunk, branching near the ground. It attains often a height of sixteen or eighteen metres (fifty feet), and resembles, in its botanical characters, *T. balsamum*, described in the succeeding article. It is a native of Central America, and protected, but not really cultivated, as a source of the balsam, in the Indian reservation lands of San Salvador, along the Balsam Coast. It has been introduced into Ceylon, where it flourishes vigorously.

Balsam of Peru was one of the earliest products carried to the Old World from Central America, and was at first extravagantly prized for its medicinal properties, as well as for its use as incense in the Catholic churches. It was at first exported indirectly, by way of more southern South American ports, and by this means it received its misleading name of balsam of *Peru*. None genuine is now, or ever has been, produced in the state of Peru.

The collection is made in November or December, at the end of the rainy season, when the bark is full of resin. The Indians, to whom the trees belong, then beat the trunks on four sides with the heads of their axes, or with hammers, so as to bruise four strips of bark, and leave as many similar ones untouched. After a few days, they scorch or ignite the contused surfaces with torches, which serves to increase the flow of resin, and then, waiting another week, tear off the loosened strips of bruised bark and swathe the stems in rags, to absorb it. When the cloths are saturated, they are boiled in a vessel of water, and the balsam melted out of them collects in the bottom, and is easily separated. The trees are not killed by the process. The following year the remaining portions are similarly treated; and in the second year those operated upon first; so, by judicious treatment, a continuous annual yield is obtained.

Balsam of Peru is a dark, thickish liquid, looking at a little distance like dark molasses; it does not draw out

into a thread and is not sticky; when shaken up upon the sides of a containing glass, the thin layer so obtained is yellowish or reddish brown and transparent. Its specific gravity is 1.135 to 1.50 at 15° C. A specific gravity of 1.137 or higher will exclude the more important adulterants. It has a rather smoky but not unpleasant balsamic, and a slightly vanilla-like odor, and a taste which, at first mild, becomes later, in the fauces, warm and acrid. It is insoluble in water, yielding to it only a little free cinnamic acid, but mixes freely with chloroform and absolute alcohol. It does not dry or undergo much change upon exposure to the atmosphere, and should contain no fat. Thirty per cent. of it should dissolve in benzin.

The composition of the balsam is not very simple, but the principal constituents are: (1) not more than thirty-two per cent. of a resin insoluble in carbon disulphide, and which may be separated by means of that agent; (2) nearly sixty per cent. of cinnamein, a brownish, aromatic liquid (benzylic cinnamate, which this is supposed essentially to be when pure, is a crystalline solid); (3) traces of cinnamic and benzoic acids and more or less styrol and styracin. Additional amounts of benzoic and cinnamic acids, with styrol and toluol, are obtained on dry distillation. Benzoate of benzyl also occurs in varying amounts. At least sixty-five per cent. of it should consist of aromatic substances. Balsam of Peru has no specific physiological action. It is a mild carminative and diffusive stimulant, and acts as an antiseptic, especially in excretion through the urinary passages. Locally, it is mildly parasiticidal, and it acts as a disinfectant and stimulating application to wounds and ulcers which lack a disposition to heal. For the latter purpose, a ten-per-cent. solution in castor oil or vaseline is used. The dose is 0.6 to 2.0 c.c. (♏ x. to xxx.). There is no official preparation. The volatile oil, distilled off, is an article of commerce used in perfumery. *Henry H. Rusby.*

BALSAMUM TOLUTANUM.—*Balsam of Tolu.* "A balsam obtained from *Toluifera Balsamum* L. (fam. *Leguminosæ*)" (U. S. P.).

This is a fine, large evergreen tree, with a tall, straight stem, often rising from thirteen to nineteen metres (forty to sixty feet) without a branch, then bearing a fine round crown. It has alternate, glandular, odd-pinnate leaves of from seven to eleven divisions, and small flowers, in axillary racemes, not very irregular. It differs from the last chiefly in the more tubular calyx and in the fruit, which is not narrowed, but winged at the base. The leaves contain abundance of fragrant oil, the branches and stem are filled with oil and resin. It is a native of Venezuela and New Granada. The balsam has been exported from the latter state since the middle of the sixteenth century. It is collected by the Indians, and was already an object of value among them when the country was discovered. Deep **V**-shaped incisions are made in the trunk, and at or below the point where they meet a vessel is fastened to receive the exudation. These receptacles are usually calabashes or gourds, and many such may be arranged at the same time around the stem of a large tree. As they become filled, they are emptied into leather bags, in which they are carried to the market or town, and there again they are at present usually emptied into tin cans for exportation.

It is a soft brown, resinous substance, when fresh sometimes thin enough to pour; usually soft enough to be dipped out with a spoon or spatula, but upon exposure becomes harder and finally brittle, although easily softened by warmth. It has a brown color, but in thin layers is yellowish, and either transparent or cloudy, by the deposition of crystals of cinnamic acid. The odor is delicate and very pleasant, recalling that of Siam benzoin, and improves with age. The balsam is almost insoluble in water, but freely soluble in alcohol and chloroform. Its most important constituent is benzyl benzoate, a volatile oil, but solid at a temperature below 20° C. There are also some benzyl cinnamate, traces of cinnamic and benzoic acids, and a variable amount of resin, usually nearly ninety per cent. About one per cent. of a volatile oil (tolane) is obtained upon distilling with water. The resin can be separated into two resins by treatment with alcohol.

The medicinal qualities of tolu are even less marked than those of Peru balsam, as the acrid quality of the latter is almost wanting in the former; still it is very much the more in use, on account of its pleasant odor and taste. It is usually called expectorant, etc., and is a common ingredient in cough and similar mixtures, but in a form which is medicinally wholly inert, further than for a passing local effect upon the fauces. If given with any expectation of modifying the bronchial surfaces, it must be in doses of not less than 1 or 2 gm (1 to 2 gm. = gr. xv. ad xxx.), or, probably, better by vapor. Of the preparations, the syrup has a strength of one per cent., and that of the oil and crystallizable acids only, not of the resin. It is simply a vehicle. The tincture, *Tinctura Tolutanum*, U. S. P., strength ten per cent., represents the entire balsam, but contains a large dose of alcohol in addition to the medicine in question. In the compound tincture of benzoin (*Tinctura Benzoini Composita*, U. S. P.) it is a subordinate adjunct. So the best ways to give the balsam internally and alone are by pill or an emulsion extemporaneously made. Both this and the preceding balsam are used in toilet soaps and for similar purposes, as perfumes, etc. *W. P. Bolles.*

BALTIMORE, MD.—The chief city of Maryland, with a population of 530,000. It is picturesquely situated on the north branch of the Patapsco River, 14 miles from its entrance into Chesapeake Bay, and about 200 miles from the ocean. It is a large manufacturing and commercial centre, and has a capacious and safe harbor. It is the seat of the great Johns Hopkins University and Hospital, is well built, and has a large park of 680 acres (Druid Hill Park). It is about 40 miles from Washington and 100 miles from Philadelphia. It is said to be a very healthy city, and has a mild climate, as the following table indicates:

CLIMATE OF BALTIMORE, MD., LATITUDE 39° 18′, LONGITUDE 76° 37′. PERIOD OF OBSERVATION, 13 YEARS; ELEVATION OF PLACE OF OBSERVATION ABOVE SEA LEVEL, 14 FEET.

Data.	January.	July.	Year.
Temperature—Average mean or normal	34.6° F.	78.5° F.	55.5° F.
Average daily range	13.5° F.	16.8° F.	
Mean of warmest	40.5° F.	86.8° F.	
Mean of coldest	27° F.	70° F.	
Highest or maximum	71° F.	99° F.	
Lowest or minimum	6° F.	59° F.	
Humidity—Average mean relative	70.8%	64.3%	66.4%
Precipitation—Average in inches	3.05	4.06	41.98
Wind—Prevailing direction	N.W.	S.W.	N.W.
Average hourly velocity in miles	5.5	5.6	5.8
Weather—Average number of clear days	7	9.2	108
Average number of fair days	13.2	14.5	151.7
Average number of fair and clear days	20.2	23.7	259.7

Explanation of Temperature.—The average mean or normal temperature is deduced from the mean temperature of individual months, obtained from three daily observations, viz., at 7 A.M., 3 P.M., and 11 P.M. For example, the mean temperature for all the Januarys of the twelve years was 31.5° F. at 7 A.M.; 38.2° F. at 3 P.M.; and 34.2° F. at 11 P.M. Adding these together and dividing by three we have 34.6° F. as the average mean January temperature for the period.

The mean of the highest temperature for any given month is the average daily maximum temperature of all the days of that month throughout the entire period of observation. Thus, for example, in the period of thirteen years there are, for the month of January, 13 × 31 = 403 days, and 40.5° F. represents the maximum height which the thermometer may be expected to reach on each of these days. This temperature, therefore, represents the maximum temperature of a normal January, day. In the same way the mean of the coldest is obtained; if we subtract one from the other we have the average daily varia-

tion or range of temperature. In this case, for instance, it is 13.5° F. for January. The highest or maximum temperature is the highest reached upon any day of the given month in any year of the period; for example, 71° F. was the highest temperature in any day of any January of the period. The lowest or minimum is the lowest reached on any day—*e.g.*, 6° F. in this case. These extremes, as Dr. Richards remarks, represent the "chances" the invalid has got to take in any resort; they do not indicate what temperature he may expect, but what it may be his good or evil fortune to encounter.

The other terms used in the table are self-explanatory.

Edward O. Otis.

BAMBOO BRIER.—Under this name the tuberous roots of *Smilax Pseudo-China* L. (fam. *Liliaceæ*) are quite extensively used in the Southern States as a substitute for sarsaparilla, their near relative. *H. H. Rusby.*

BANDAGING.—Bandages are used for the following purposes: to apply firm pressure, to secure splints or dressings, to afford support, or to correct deformity. They are made of almost any fibrous material, as gauze,

FIG. 454.—Position of Hand in Rolling Bandage.

flannel, unbleached muslin, or cheese-cloth; but whatever the material, it must be both strong and supple. The most commonly used bandage is the "roller" bandage; and it is to this kind that the following remarks are applied. This is of various lengths and widths, according to the parts to which it is to be applied. Thus, for digits the roller should be three-quarters of an inch wide, and two or three yards long; for upper limb and head, two to two and a half inches wide and about six yards long; for lower limb, two and a half to three inches wide and about eight or nine yards long; for the trunk, four to six inches wide and about ten yards long. The material must be *torn* into strips and have neither selvage nor seams.

To make a "roller," turn about six or eight inches of bandage upon itself, and then roll this upon itself till it is a hard and firm cylinder; this forms a centre around which as much more material as is necessary can be rolled. This rolling is accomplished by holding the two poles of the cylinder between the thumb and fingers of the left hand, while the unrolled part passes between the thumb and index finger of the right hand. The left hand is alter-

FIG. 455.—Method of Rolling Bandage.

nately supinated and pronated, the cylinder gradually getting larger (see Figs. 454 and 455). The centre cannot be displaced from a properly rolled bandage. Bandages were formerly rolled by hand, but this wearying and tedious method is now replaced by some simple form of machinery.

Bandaging cannot be learned from a book, but a few general rules may prove of service. The surgeon should face the patient and not stand at the side of the limb. The limb should be placed in the position it is to occupy when it is bandaged. The external surface of the roller is to be applied to the part; it should pass from the inner side, over the front, to the outer side, and from below upward. If the left limb is to be bandaged the surgeon should use his right hand, and *vice versâ*; hence the ambidextrous man has the advantage. Use a narrower bandage in preference to a wider

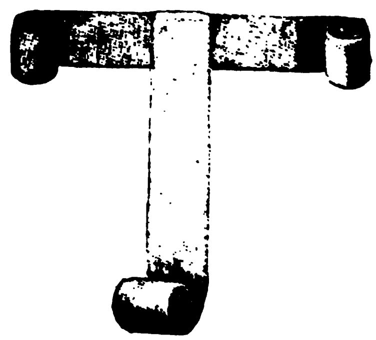

FIG. 456.—T Bandage.

FIG. 457.—Oblique Bandage.

one, except in bandaging the trunk. Bind firmly, evenly, and tightly, but not too tightly.

Bandages have been *named* from their use (as suspen-

sory of breast), application (as spiral, circular), shape (as figure-of-eight), originator (as Barton, Gibson, etc.).

FIG. 458.—Spiral Reversed, I.

Many names and varieties formerly used are now obsolete, as Dolabra, Ascia, etc.; and others are obsolescent. The modern tendency is toward simplicity; and bandaging is no longer the fine art it was once considered. The elaborate details formerly indulged in are not now considered necessary. For our present purpose bandages may be considered as—

1. *Simple*, including circular, oblique, spiral, spiral reversed, spica, figure-of-eight, recurrent.

FIG. 459.—Spiral Reversed, II.

2. *Compound*, including T (single and double), four-tailed, many-tailed, and handkerchief.

1. *Simple.*—(*a*) *Circular*, in which each turn exactly covers the previous turn. This is used for cylindrical parts of the body as the forehead, neck.

(*b*) *Oblique*. This is used to retain dressings loosely applied (as in burns); the succeeding turns do not overlap at all (see Fig. 457).

FIG. 460.—Spiral Reversed, III.

(*c*) *Spiral*, in which each turn overlaps about one-third of each previous turn. Used for conical parts of the body, but is now largely replaced by—

(*d*) *Spiral reversed*. As in above (*c*), the upper edge is tight, while the lower is loose, the spiral reverse was introduced to remedy this defect. To make a reverse, the bandage must be kept rolled up with three or four inches of slack only, and the bandage retained in place by finger and thumb; without traction turn the bandage down with a good slope downward, so that it is well doubled over. Some little practice is necessary to get the knack of doing this neatly and well. The commonest error is in

FIG. 461.—Spiral Reversed Completed.

holding too tightly what should be the "slack," and in not making sufficient slope. Figs. 458 to 461 show this bandage in progress and completed.

FIG. 462.—Testudo Inversa.

FIG. 463.—Testudo Reversa.

(*e*) *Figure-of-eight* looks on completion much like a spiral reversed, but its application is not the same. It is used over a joint or on the length of a limb, but care must be taken to have a wide sweep and open loops to the 8; it is also applicable to projecting points, and to the junction of a limb with the trunk; in this latter position it is often called—

FIG. 464.—Head Bandage.

(*f*) A *spica*, the succeeding and overlapping turns being supposed to resemble an ear of corn (*spica*). There are many varieties of spica: ascending, descending, anterior, posterior, lateral, single, double.

(*g*) *Recurrent*. Used for amputation stumps and the head. For description see below.

(*h*) *Testudo* is a modification of figure-of-eight used about an articulation. In the testudo *inversa* the spirals overlap from without inward, the last turns covering the centre of the joint; while in the testudo *reversa* the first turn passes over the centre of the joint, and the spirals diverge therefrom (see Figs. 462 and 463).

FIG. 465.—Bandage of Galen.

HEAD. — *Recurrent bandage.*—Take a roller and make two circular turns round forehead; then at centre of forehead hold bandage, give it half a turn, take it over to occiput, have an assistant hold it there, and then after half a turn go forward again to forehead, just overlapping a portion of the previous turn. Continue this until the scalp is covered all over, and finish with two circular turns round the forehead; insert a few pins where the pieces overlap (see Fig. 469). A similar proceeding is used for an amputation stump.

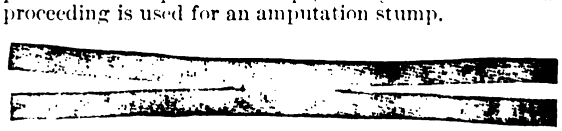

FIG. 466.—Four-Tailed Bandage.

Galen's bandage, sometimes called poor man's bandage, or six-tailed bandage, is very easily made and applied. Take a piece of cloth or handkerchief wide enough to reach from the occiput to the eyebrows and long enough to come down and meet under the chin. Each side is cut into three strips or tails, leaving a whole piece of from four to six inches on top of the scalp. Then putting the bandage in place take the two middle tails and fasten

FIG. 467.—Velpeau's Bandage.

them under the chin, bring the two anterior tails backward and the two posterior ones forward, and fasten them over the temporal region (see Fig. 465).

Four-tailed bandage (for scalp and fracture of lower

FIG. 468.—Desault's Bandage, I.

FIG. 469.—Desault's Bandage, II.

jaw) (see Fig. 466).—Fit the centre snugly over the chin, take the two under tails and bring them up over the top of the head well forward, and tie them tightly there; then bring the upper tails and tie them tightly over the lambda. Finally, tie these two knots together. Considerable pressure can be obtained with this bandage.

Barton's bandage (for fracture of lower jaw).—Begin at external occipital protuberance, go outward, upward over right parietal bone, across vertex, down left side of face in front of ear, under chin, and up the right side of the face in front of ear to vertex, then over left parietal bone to starting point. Now take a turn round right side of jaw across chin, round left side of jaw, back to nucha, and up to occipital protuberance. Repeat from beginning and fasten at points of junction.

For Eye.—Place a narrow bandage over head and let it hang down in front of *sound eye;* then over this pass a circular bandage round both eyes. Fasten the posterior end of the narrow slip to the circular bandage, and lift the anterior end of the narrow slip and fasten it on itself, thus covering the sound eye (this is called Borsch's bandage).

FIG. 471.—Lower Extremity Bandaged.

FIG. 470.—Desault's Bandage, III.

FIG. 472.—Spica of Groin.

Banff Hot Springs.

UPPER EXTREMITY.—Take two circular turns about the wrist, then go obliquely across the dorsum of the hand to the extremity of the fingers, then by spirals and reverses ascend the hand to the root of the thumb. A few figure-of-eight turns will cover the wrist; the forearm is covered by spiral reverses, the elbow by a testudo or figure-of-eight, and the arm by spiral reversed turns.

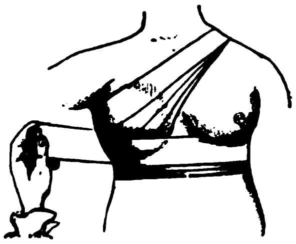

FIG. 473.—Breast Bandage.

For a *finger* or *fingers separately* use a roller of three-quarters of an inch thick, take two or three circular turns round the wrist, then go across the dorsum of the hand to the root of the finger, then take oblique turns to the tip of the finger; here take a circular turn and then by means of spiral reverses reach the base of the finger and finish by figure-of-eight turns between finger and wrist, and a couple of circular turns around wrist.

Velpeau's bandage for fractured clavicle, which was formerly much employed, is now seldom used, being replaced to a large extent by adhesive plaster. It is shown in Fig. 467.

Desault's bandage, also much in vogue formerly, is now fast disappearing; it was cumbersome with its three rollers, axillary pad, and sling.

The pad was either too small to be of much use, or else large enough to be injurious. Illustrations of this bandage can be seen in Figs. 468, 469, 470.

LOWER EXTREMITY.—Take two circular turns round ankle, and an oblique across dorsum of foot to the toes; make a circular turn here, and with spiral reverses cover the foot; take figure-of-eight round ankle, spiral reverse up leg; treat knee with figure-of-eight, and thigh with spiral reverses (see Fig. 471). If the heel is to be covered a testudo can be employed.

Spica of Groin.—Place a layer of cotton in the groin to prevent irritation. Begin with a couple of circular turns around the waist away from the hip to be bandaged, then down over the front of the thigh from without inward, then around back of thigh and up over the front of the groin and around waist. This plan is repeated, each turn overlapping one-third of previous turn; and finally a circular turn is taken round the waist (see Fig. 472).

Double spica of groin is more of a curiosity than of practical utility.

Spica of Shoulder.—Two circular turns and spiral reverses round upper arm from behind forward, go over the shoulder across front of the chest under opposite axilla and return across the back to the shoulder whence it started; repeat this five or six times. This is a figure-of-eight, the large loop going round the chest.

Bandage of Breast.—Take the roller round the waist below the breast, commencing in front and passing toward sound side; then ascend over lower part of injured breast to opposite shoulder, returning by axilla to horizontal turn where it passes round the waist again. The oblique turns over the breast are continued and carried up to the shoulder till the gland is entirely covered (see Fig. 473).

Another simple *bandage of breast*, equally effective for compression and support, is made of a wide strip of cloth passed round front of chest over one or both breasts, under arms, and meeting at back, where by means of eyelets and lacing considerable pressure can be exerted.

T bandages (Fig. 456) are made of two strips fastened to each other at right angles; this bandage is chiefly used in keeping dressings in the perineum. The transverse part is fastened round the body, and the tail or tails brought up between the thigh and genitals and fastened to the transverse part. Those who want the "newest thing" in bandages can be referred to the "new T bandage," described in the *Medical Record* for February, 1900, p. 232.

Fixed dressings, plaster-of-Paris bandages, and handkerchief dressings will be described under article on *Dressings, Surgical*.

R. J. E. Scott.

BANFF HOT SPRINGS.—LOCATION.—Rocky Mountains, Canada.

POST-OFFICE.—Banff, Alberta.

ACCESS.—From the east or west, viâ Canadian Pacific Railway.

According to the analysis of F. D. Adams, of the Geological Survey of Canada,

ONE IMPERIAL GALLON CONTAINS:

Solids.	Grains.
Chloride of sodium	0.771
Sulphide of soda	0.624
Sulphide of potassium	0.673
Sulphide of magnesia	14.504
Sulphide of lime	39.428
Bicarbonate of lime	11.583

FIG. 474.—View of Hotel at Banff.

Banff Hot Springs.

FIG. 475.—Bow River Valley in the Vicinity of Banff.

FIG. 476.—The Hot Springs Basin at Banff.

Solids.	Grains.
Bicarbonate of iron	0.126
Alumina	Undetermined.
Silica	2.789
Organic matter	Trace.
	70.498
Carbonic acid, free	3.041
	73.539

The waters also contain sulphureted hydrogen to the amount of 0.3 grain, equivalent to 0.8 cubic inch.

These well-known hot sulphur springs are situated on the line of the Canadian Pacific Railway near the eastern face of the Rocky Mountains. They are in an extensive reservation held by the Canadian Government as a national park. The waters are the property of the Government and are supplied to the sanitarium and the hotel. At the springs the waters are free to the public. The springs are two in number, and issue from the mountain-side at about 800 and 1,000 feet above the Bow River, which flows through the valley, and 4,500 feet above sea level. The flow of water is continuous; that from the upper and hotter spring would form a cylindrical stream five inches in diameter. The lower spring is much larger, and issues from a large cave in which is formed a natural basin some six feet in depth. The temperature of the water remains about the same all the year, that of the upper spring being 114° F. and that of the lower 95° F.

A large modern sanitarium has been erected, and every form of steam and hot-water bath is provided. The proprietor resides on the premises, and, with the aid of a staff of assistants, directs the use of the waters.

A very large and comfortable hotel has been erected by the railway company for the accommodation of tourists and visitors. It also affords every facility for baths and other uses of the water. The surrounding country is a series of snow-clad peaks, which possess all the grandeur of the mountain range, and a number of Swiss guides are kept to assist those who may desire to explore the mountains. Facilities for hunting and fishing are unsurpassed.

The air is exhilarating and the climate very favorable, the heat of summer and the cold of winter rarely being excessive. There are few places on this continent where the conditions for carrying out the high-altitude cure are as favorable as they are at Banff. The following record is taken at the Government observatory on the spot:

BANFF, ALBERTA, N. W. T., LATITUDE N. 51 10'. LONGITUDE W. 115° 35'. HEIGHT ABOVE SEA LEVEL, 4,542 FEET.

Months.	Pressure.			Temperature.			Rain, inches.	Snow, inches.	Precipitation, total.
	Monthly Mean.	Extremes. Max.	Extremes. Min.	Mean.	Extremes. Max.	Extremes. Min.			
January	25.22	25.61	24.90	16.4	30.2	-8.9			
February	25.19	25.73	24.63	19.3	44.2	-23.2	....	24.65	2.47
March	25.25	25.63	24.89	17.9	41.8	-27.3	....	9.95	0.99
April	25.32	25.71	24.80	36.6	65.1	7.8	0.81	....	0.81
May	25.31	25.67	24.96	44.9	72.4	20.8	3.08	....	3.08
June	25.35	25.87	25.09	51.1	80.1	30.2	2.15	....	2.15
July	25.38	25.63	24.96	56.2	85.3	30.5	4.54	....	4.54
August	25.39	25.59	25.12	59.9	85.2	32.0	2.37	....	2.37
September	25.32	25.79	24.94	48.0	73.3	24.8	1.73	....	1.73
October	25.39	25.79	24.89	35.0	47.6	15.8	1.09	....	1.09
November	25.20	25.63	24.76	20.9	41.8	-15.8	0.07	8.65	0.93
December	25.36	25.85	24.76	19.2	48.0	-25.5	0.09	1.08	0.20
Year	25.30	25.71	24.89	35.5	85.3	27.3	15.93	44.33	20.36

NOTE.—Barometer not reduced to sea level.

The number of invalids who are sent to these springs is increasing each year, and the locality promises to become one of the most desirable health resorts on the continent.

Beaumont Small.

BAÑO DE SAN PABLO.—These baths are located in the city of Pueblo, Mexico. The water contains the following mineral ingredients: chloride of sodium, sulphate of alumina, chloride of magnesium, carbonate of calcium, sulphate of calcium, silica, hydrosulphuric acid, and carbonic acid—a total of about 100 grains per United States gallon. The baths here enjoy a wide reputation in Mexico on account of the exceptional excellence of the bathing establishment and also on account of the location in Pueblo, which, in the writer's experience, is the most attractive of all the Mexican cities.

N. J. Ponce de Léon.

BAÑOS DE LAS ARENAS.—Chucandiro, Michoacan, Mexico. This is a large thermal spring having a temperature ranging from 99° to 106° F. The water is clear, slightly yellow in color, and has a neutral reaction and a sulphurous odor.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	22.98
Magnesium sulphate	7.28
Calcium sulphate	8.16
Sulphurous acid	.03
Carbonic acid	.30
Total solids	38.75

The analysis is evidently incomplete. The spring discharges more or less hydrogen sulphide and appears to be of the calcic-sulphureted type. Two bathing apartments have been constructed. It is claimed by residents of the locality that the baths are very beneficial in skin diseases and in various forms of neuralgia and rheumatism.

N. J. Ponce de Léon.

BAÑOS EN EL PEÑON.—These celebrated springs are situated four kilometres northeast of the city of Mexico, and their birth, according to the Aztec legend, was coeval with that of the city. The water furnished by the Baños en el Peñon issues from the side of the Peñon mountain. The earth here is composed chiefly of lime deposits interrupted in places by overflows of lava and beds of sandy clay. The flow of water is considerable, and this may be increased almost indefinitely by means of pumps. The water has an average temperature of 114° F., which never varies more than two or three degrees higher or lower. The physical characters are as follows: Perfectly clear, colorless, odorless, slightly saline and pungent—reaction at first slightly acid, afterward alkaline. A solid residue of 130 grains per United States gallon remains after evaporation at 100° C. (212° F.). This residue has been found to consist of the sulphate, the phosphate, and the bicarbonate of calcium, the bicarbonates of magnesium, sodium, potassium, and iron, the chloride of sodium, alumina, manganese, lithia, boric acid, iodine, and organic matter. The water also contains nitrogen, oxygen, and carbonic acid gases, the latter of which is freely discharged as the water flows from the spring.

Cementerio en el Peñon.—This is an artesian well which owes its name to the fact that it is located near an old cemetery. It is about 230 feet in depth. Its waters are also warm like those of the Baños spring. The water is somewhat opalescent in appearance, has a markedly sulphurous odor, and a somewhat pungent and saline taste. Temperature, 99.5° F. Reaction first acid, afterward alkaline. Total solid contents per United States gallon, 96.19 grains—consisting of calcium sulphate, calcium phosphate, calcium bicarbonate, magnesium bicarbonate, sodium bicarbonate, potassium bicarbonate, iron bicarbonate, sodium chloride, silica, alumina, and traces of sodium sulphide, lithia, manganese, iodine, hydrosulphuric acid, and organic matter. Gases present: carbonic acid, nitrogen, and oxygen. A third spring, known as the "*Manantial del Horno*" *en el Peñon* is situated in the neighborhood. This is a heavily carbonated thermal spring. Its waters are very similar to those of the Baños, but are evidently a little more densely mineralized and are not quite so hot. These springs may be classified as of the alkaline-saline-carbonated type, resembling somewhat those of Wiesbaden, Kissingen, and Ems in Europe, and not unlike the Saratoga waters in the United States. According to Dr. Liceago, of Mexico City, the baths of

El Peñon are useful in a great variety of diseased conditions, including particularly subacute and chronic muscular rheumatism, gout, migraine, various neuralgias, diabetes, obesity, and chronic affections of the gastro-intestinal tract and liver. The springs have a delightful location in the valley of Mexico at an elevation of 3,000 metres above the sea level. This may be called a region of perpetual spring. During the writer's sojourn in the valley in the months of November and December the atmospheric conditions were very similar to those obtaining in New York in the month of May. The baths here may be employed all the year round. The water is also highly recommended by Mexican physicians for internal use. It should be sipped hot at the springs, beginning in doses of half a tumblerful two or three times a day and gradually increasing the quantity.

N. J. Ponce de Léon.

BARBADOS.—The island of Barbados (also spelled Barbadoes) lies farthest to windward, *i.e.*, to the eastward, of any of the Windward Islands, in Lat. 13° 4′ N., Long. 37° W. For nearly three hundred years the island has been in the possession of the English Government, and Bridgetown, its capital and largest town, is one of the chief commercial centres of the West Indies. The annual sugar crop of Barbados is estimated at about forty thousand hogsheads, and the whole island is under cultivation, the population being very dense (nearly a thousand per square mile). The length of the island, from north to south, is about twenty-one miles, and at its broadest part it extends some fourteen and a half miles from the eastern, or windward, to the western, or leeward shore. "Barbados presents every variety of scenery—hill and valley, smooth tableland, and rugged rocks. From one point of view the land rises in a succession of limestone and coral terraces, which indicate different periods of upheaval from the sea. From another there is nothing to be seen but a mass of abruptly rising rocks. The highest elevation, Mount Hillaby, is 1,104 feet above the level of the sea. The island contains but few streams or streamlets. The gullies or ravines—the result, no doubt, of volcanic agency—are, however, very numerous, radiating from the high semicircular ridge of the coralline formation in a very regular manner to the west, north, and south, but not to the east, where the coral rocks end abruptly. . . . The climate of Barbados is healthy; the temperature equable. For eight months in the year the sea breezes keep it delightfully cool for a tropical country. The extent of cultivation, the absence of swamps (the porous character of the rock immediately underlying the soil preventing accumulations of stagnant water), account for the freedom from miasma" (Encyclopædia Britannica). "The northeast trade wind prevails throughout three-fourths of the year, and the rains also come for the most part from the northeast; but at certain times of the year the wind shifts to the southwest and northwest, bringing showers which, however, do not extend across to the windward, or northeast, side of the island. Indeed, it is only exceptionally that rain coming from any direction falls at one and the same time throughout the entire extent of the island. March is the driest month, October the most rainy. . . . During the dry season, December to June, the lowlands on the leeward side of the island have a smaller rainfall than do the other districts; but during the wet months (July to November), when the westerly winds are of most frequent occurrence, the rainfall of these districts exceeds that of other portions of the island" (Hann's "Handbuch der Klimatologie," p. 356).

The average rainfall for each of the twelve months of the year is given in a table to be found on p. 349 of the work just quoted, the figures being as follows:

January	3.267 inches.	July	5.708 inches.
February	2.605 "	August	7.244 "
March	1.456 "	September	6.221 "
April	2.007 "	October	8.766 "
May	3.543 "	November	7.086 "
June	5.433 "	December	4.487 "
Year	57.757 inches.		

As we learn from the figures of this table, the total rainfall in Barbados for the six months of December, January, February, March, April, and May is only 17.36 inches, or an average amount of but 2.89 inches per month. The temperature in Barbados, as in all other tropical islands, varies but little throughout the year. According to the writer in Appleton's "Handbook of Winter Resorts," the thermometer ranges in December from 73° to 85° F., and in February, from 71° to 84° F. A letter from the Superintendent of the Canadian Meteorological Service, which was kindly obtained for the writer by the Hon. Beaumont Small, of Ottawa, in reply to inquiries concerning the climatological statistics of the British West Indies, alludes to the climate of Barbados as follows:

"The mean monthly temperature ranges from 76° F. in January to 80.8° F. in August. The rainfall varies greatly from month to month, but is never wholly absent; the total yearly amount, from an average of twenty-five years, was 57.74 inches. The average for March exceeds 2 inches, and in October reaches nearly 11 inches, these being respectively the driest and wettest months of the year." The mean annual relative humidity is 72 per cent., as is also the mean for the winter.

Huntington Richards.

[There is no system of drainage at Barbados outside of the garrison, but it is said (Hutchinson) that the porous nature of the land renders this unnecessary. The town and suburbs are supplied abundantly with pure drinking water. Residence in Bridgetown itself is not to be recommended to invalids, but one may safely select either Hastings or Fontabelle, in the suburbs, or Scotland, which is considered the healthiest residence portion of the island. Cases of typhoid fever are occasionally encountered, and yellow fever is sometimes brought from the other islands, but there is almost perfect immunity from smallpox, diphtheria, scarlet fever, measles, and other infectious diseases. "The records of the garrison there for the last twenty-five years show that it is the healthiest station at which troops are quartered anywhere in the world" (Moxly).

The characteristics of the climate are those of an insular tropical climate, moist, bland, and equable, with only slight variations in the temperature. The northeast trade winds blow steadily during the day, and as a rule they are not unpleasantly strong. During the dry season from December to May, there are no rains or heavy dews. Although sunstroke is said to be rare, it is wise to follow the custom of the natives and carry a sun umbrella during the hottest hours of the day—from eleven to four.

Such a climate as this is manifestly unsuited for cases of pulmonary tuberculosis. "It is more than useless," says one who has had a large experience with this climate, "to send consumptives to these islands." There are various conditions and diseases, however, which are greatly benefited by a residence here; such are the various forms of nervous prostration, or mental fatigue, neurasthenia, chronic renal diseases, the various cardiac derangements or diseases, catarrhal and irritative affections of the throat, and laryngitis. Such a climate is also very suitable for old people or those possessing little vitality, and for weakly children. It may also be recommended to those who desire to avoid the risk of bronchitis or other acute respiratory affections so common in northern latitudes. "Tropical islands," says Hutchinson, "are bad places for rheumatism; the same constant moisture that plays so large a part in curing nervous difficulties produces and intensifies all forms of rheumatic affections."

Sea bathing is one of the features of this island, the temperature of the water being about 78° F. At Hastings there is a reef of coral which protects bathers from the sharks. The accommodations are good, and one finds competent medical men there.

Barbados is reached from New York in five or six days, and the island has frequent communication with England and the other islands.—*E. O. Otis.*]

BARGER'S SPRINGS.—Summers County, West Virginia.

POST-OFFICE.—Talcott.

ACCESS.—Viâ Chesapeake and Ohio Railroad to Talcott, thence a drive of three miles to the springs. Private boarding-house.

Barger's springs have their situation in a picturesque, broken region, marked by ragged cliffs and narrow shaded glens, with numerous rapid mountain streams dashing through them. The Greenbrier River, a stream famous for its charm of scenery and for the enticements it affords to the angler, flows within two hundred yards of the springs. The place has not been much improved as yet, and the only stopping place for visitors is a boarding-house with a limited capacity. No analysis of the water has been made, but it is evidently thoroughly charged with sulphureted hydrogen. Residents of the locality resort to it for the treatment of atonic dyspepsia. It is quite beneficial in chronic rheumatism, and a number of very obstinate cases of cystitis appear to have yielded to its use. The water also possesses tonic properties, and is a useful adjunct in debilitated states. Its temperature is 58° F. *James K. Crook.*

BARIUM.—Salts of barium are of more interest to the physician from the point of view of toxicology than from that of therapeutics. Barium compounds are all poisonous, the soluble ones, of course, more actively so than the insoluble. Therapeutically, barium has been assumed to have a power over scrofulous conditions analogous to that of iodides or of mercurials, but no striking results have ever been demonstrated from its use. The *chloride* is the only barium salt of medicinal interest.

Barium Chloride, $BaCl_2$, $2H_2O$.—Barium chloride is not now official in the United States Pharmacopœia. It is a white, crystalline salt, occurring in rhombic tablets, permanent in the air. It dissolves freely in water and diluted alcohol, and has a bitter, disagreeable taste. It has been given medicinally in doses of from 0.03 to 0.13 gm. (gr. ss. to ij.), dissolved in an abundance of water.

Barium Dioxide, BaO_2, is official in the United States Pharmacopœia for pharmaceutical use in preparing the official *Aqua Hydrogenii Dioxidi*, Solution of Hydrogen dioxide. *Edward Curtis.*

BARIUM SALTS. (TOXICOLOGY.)—Several of the soluble salts of barium, especially the nitrate $Ba(NO_3)_2$ and the chloride $BaCl_2$, are used largely in the chemical laboratory as tests for sulphuric acid. The compound, however, which is most familiar in commerce is the sulphate $BaSO_4$, which is known as *barytes* or *heavy spar*. This is a heavy, white, opaque substance, much employed as a general adulterant on account of its weight, but especially for mixing with and adulterating paints. Its high degree of insolubility deprives it of any specific poisonous action, except possibly as a mechanical irritant. It has been stated that it has been used in flour, and even in butter, but such use must be rare.

The soluble barium compounds, especially those above mentioned, are irritant poisons. Cases of poisoning by them are, however, rare, and have been mostly the result of accident, the body having been mistaken for one of the ordinary saline cathartics.

Barium carbonate is used as a rat poison, but a case on record shows that it is not a very virulent body.

In the recorded cases of poisoning by barium salts the quantities taken have usually been rather large, varying from one hundred grains to half an ounce. The symptoms—which do not arise immediately—are those of irritant poisoning, nausea, with sharp burning pains in the stomach, followed by vomiting and purging. Loss of muscular power has been noted in some of the cases, but most have exhibited convulsions toward the end. No characteristic brain symptoms are developed, but giddiness and headache have been observed.

Post-mortem examination shows the usual appearances of irritant poisoning, inflammation of the mucous membrane of the stomach and bowels, and extravasation of blood.

Death has usually occurred in less than twenty hours, in some cases even in two hours.

The antidote in poisoning by barium salts is any soluble sulphate, such as Epsom salt, Glauber's salt, or alum. These form at once the insoluble and inert barium sulphate, which can easily be removed from the stomach by the promotion of vomiting. The poison will be completely neutralized by the antidote, and the subsequent treatment will be on general principles.

There is no difficulty in recognizing a barium salt. Sulphuric acid or any soluble sulphate produces at once an opaque, white precipitate of barium sulphate, distinguished by its entire insolubility in water, in acids, or in alkalies. *Henry Leffmann.*

BARIUM SPRINGS.—Iredell County, North Carolina.

POST-OFFICE.—Barium Springs.

ACCESS.—Viâ A. T. and O. Railroad (Southern System) to Barium Springs station, thence one-half mile to the springs. The location is five miles from Statesville and forty miles from Charlotte. Farmhouses receive visitors.

This spring has been known since 1775. From the fact that cattle refused to drink from it the spring was formerly known as "Poison" spring. It is located on the top of a rocky knoll, about fifteen feet higher than a brook not over forty feet distant, and eight to ten feet higher than eight other springs around the base of the knoll and over one hundred feet distant. The spring has no visible outlet, yet the water remains at a constant level, never freezing and never stagnating.

According to an analysis by Professor Ledoux it contains seventeen grains per United States gallon of barium sulphate and chloride, phosphoric acid and iron. Professor Chandler's analysis shows the presence also of a small quantity of sulphuric acid, lime salts, and magnesia. The water is used commercially, and is said to possess value in the incipient stage of cancer, in syphilis, eczema, indigestion, ulceration of the stomach, etc. *James K. Crook.*

BARLOW'S DISEASE. See *Scurvy*.

BARTHOLIN'S GLAND.—ANATOMY AND PHYSIOLOGY.—Bartholin's gland was described by a number of the old anatomists, including Bartholin, Duverney, and Cowper, all of whose names have been attached to it by different writers. In recent years it has been studied more particularly by Tiedemann and Huguier, the latter of whom gave it the name of the vulvo-vaginal gland.

FIG. 477.—The Vulvo-Vaginal Gland and Its Excretory Duct. (After Huguier.) *a, a*, Section of the labium majus and nympha; *b*, the gland; *c*, its excretory duct; *e*, its orifice in the vulvo-caruncular furrow; *f*, the bulb of the vagina; *g*, the ischio-pubic ramus.

These glands, of the compound racemose order, are two in number, situated one on either side of the introitus vaginæ, immediately below the bulb of the vestibule, in a space bounded by the superficial perineal fascia in front, the vagina internally, and the ascending ramus of the ischium externally. Each gland is bean-shaped, usually not more than half an inch long, but sometimes (especially in prostitutes) as large as an almond. When in its normal condition it is not generally to be felt on palpation, but the mouth of its duct, of a size sufficient to admit a bristle, may commonly be seen at the bottom of the furrow which separates the ostium vaginæ from the lower end of the labium minus. The duct is rather more than half an

inch long. According to Tiedemann, the gland may wholly disappear in advanced age.

The accompanying illustration (Fig. 477), from Huguier, shows a dissection of the parts in the immediate neighborhood of Bartholin's gland, while the second cut (Fig. 478), taken from Henle, shows a front view, in section, of the external genitals of a new-born female infant in the region of the posterior commissure of the labia pudendi (left half of the posterior cut surface).

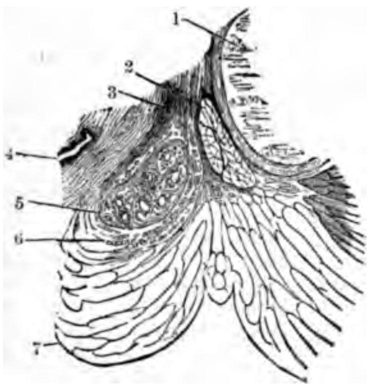

FIG. 478.—1, A section of the lower part of the descending ramus of the pubic bone; 2, the ischio-cavernosus muscle; 3, the bulbo-cavernosus muscle (in longitudinal section); 4, the vagina; 5, Bartholin's gland; 6, the bulbo-cavernosus muscle (in oblique and transverse section); 7, the labium pudendi. (After Henle.)

The gland is considered to be the analogue of Méry's gland in the male. It furnishes a whitish mucous secretion, the purpose of which is to lubricate the vulva in the act of coitus. This secretion is sometimes ejected in a jet, as the result of titillation of the vulva or erotic excitement, in the waking state or during sleep.

PATHOLOGY.—Affections of the vulvo-vaginal gland and those of its excretory duct, taken together, are exceedingly common. In general, it is the duct alone that is affected, at least in the first instance. Common inflammation, which is apt to end in the formation of pus, is one of these diseases, and inflammation may be the cause or the consequence of a distention of the duct due to retained secretion. But a still more important affection is suppuration due to gonorrhœal infection.

Dilatation of the Excretory Duct.—This condition, the so-called retention cyst, is undoubtedly often mistaken for a swelling of the gland itself, but its comparatively superficial situation is sufficient to distinguish it from the latter. Unless accompanied by inflammation or œdema of the surrounding tissue of the labium, it ought not to be confounded with any other affection, and, even when one of those complications is present, it requires to be diagnosticated only from hæmatoma and from a sero-purulent form of infiltration of the labium that sometimes takes place during the lying-in period. It may be distinguished from hæmatoma by the fact of its gradual formation, and, less readily, from puerperal infiltration by the same feature, which, however, becomes very significant when coupled with the patient's general condition and the history of the case.

The affection is most common on the left side—its immediate cause being an obstruction at the orifice of the duct; the conditions leading to the latter occurrence are various. It is very common in newly married women and in prostitutes, which fact tends to show its frequent origin in a sort of traumatism due to excessive coitus. Gonorrhœa, also, may readily give rise to it, or any catarrhal affection of the vulva, including eczema. Besides, the urine may be of so irritating a quality as readily to set up quite enough irritation at the mouth of the duct to lead to obstruction. Another cause mentioned by writers is the encroachment of condylomata upon the opening of the duct.

This form of disease tends to induce acute inflammation, and, if this does not occur, it is prone to relapse. The swelling is not always painful in itself, but it constitutes a certain impediment to coitus, and is always a source of annoyance to the patient.

Very commonly the retained secretion may be squeezed out through the orifice of the duct, and in some instances no further obstruction takes place for a considerable length of time. In general, however, dilatation by means of graduated probes is required. If this proves ineffectual or unusually difficult, it is best to cut into the swelling and pass the probes from the wound. In this case the cavity should be dressed antiseptically. When repeated relapses occur, a portion of the wall may be cut out and the remainder of the cavity cauterized, with a view of inducing suppuration and obliteration. Tincture of iodine or nitrate of silver will usually answer the purpose, but in stubborn cases good results have been secured with chloride of zinc.

Deeper-seated retention cysts, due to obstruction of the radicles of the duct within the gland itself, are much less common. In some instances they reach a very great size, extending down on the perineum and up by the side of the vagina, so high even as to press the uterus out of its natural situation, and they may be complicated with an effusion of blood into the cavity. In their treatment, it is best to remove the entire gland and its duct.

True inflammation, either of the gland or of its duct, commonly ends in suppuration, and the pain is apt to be severe, with some constitutional reaction. The abscess usually breaks on the inner side of the labium, giving exit to dirty, stinking pus. It is to be treated like ordinary abscesses; at first with poultices, and, when fluctuation is evident, by means of a free opening, preferably on the inner aspect, and the cavity should be stuffed with antiseptic gauze. When the abscess is left to itself several openings may form, fistulous tracts may remain for a long time, and undermining may occur, as with buboes. These features call for the same treatment as in other parts of the body.

Pain and hyperæsthesia of the gland are said to be the occasional result of the repeated discharge of its secretion, in consequence of erotic dreams. *Frank P. Foster.*

BARTLETT SPRINGS.—Lake County, California.

POST-OFFICE.—Bartlett Springs. Hotel.

ACCESS.—Since May 1, 1892, the springs are reached from San Francisco by two routes. First, viâ San Francisco and Northern Pacific Railroad. Leave San Francisco by the Tiburon Ferry, arriving at Pieta at 11:50 A.M. Thence by stage to Lakeport, arriving 4:15 P.M. Thence by steamer *City of Lakeport* across Clear Lake, disembarking at Bartlett station at 5:45 P.M. Thence by a second six-in-hand stage to springs, arriving at 8 P.M.—a beautiful and picturesque route throughout. Second, leave San Francisco viâ Oakland Ferry, 8 A.M., arriving at Colusa Junction at 1:25 P.M. Change to Colusa Railroad. A ride of forty-five minutes brings the visitor to Bites at 2:10 P.M. Thence take Miller and Long's stage-coach thirty-five miles to springs, arriving at 9 P.M.

These springs have been known for upward of twenty-five years and have become widely noted as a health resort. No more pure and invigorating climate can be found than that of Lake County; and the Bartlett springs, being located in a cañon, with high mountains on the north and south, are particularly well located to resist sudden changes of temperature. The thermometer shows a mean of 85° F. in the summer and is never below 20° F. in the winter; the elevation is twenty-three hundred feet above the sea level, and the surrounding scenery is grand and inspiring. On the springs property, consisting of eight hundred acres, can be found hundreds of mineral springs, no two having exactly the same composition. The following analysis of the principal spring, by Mr. George E. Colby, shows an alkaline-carbonated water of moderate strength, which possesses, especially in the sodium, calcium, and magnesium compounds, active remedial agents.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium chloride	0.50
Sodium bicarbonate	1.05
Potassium bicarbonate	.39
Magnesium carbonate	6.62
Calcium carbonate	30.14

Solids.	Grains.
Calcium phosphate	0.49
Calcium sulphate	.63
Iron compounds	Traces.
Silica	3.47
Lithium	Traces.
Borium carbonate	.05
Strontium	.00
Boric acid	Traces.
Organic matter	Traces.
Total	43.34

Gases.	Cubic inches.
Free carbonic acid	24.21
Ammonia	Faint trace.
Temperature of water	54° F.

Dr. Winslow Anderson's analysis shows slightly more solids per gallon and a somewhat smaller proportion of carbonic acid. There are other well-known springs here, including the "Soda," "Iron," "Sweet," and "Gas" springs. A feature of great interest in the neighborhood is the gas tunnel, running eighty feet into the mountain-side. A large flow of carbonic acid gas issues steadily from the mouth of the tunnel. It rises to a height of eighteen feet above the ground and by force of gravity rolls down the mountain-side in considerable volume. Many small animals and reptiles, including birds, squirrels, lizards, etc., in trying to cross its path become asphyxiated. Skeletons of some of the victims may be seen for quite a distance from the tunnel's mouth. The waters of Bartlett Springs are highly recommended in chronic rheumatism, gout, sciatica, calculous diseases, dyspepsia, and chronic alcoholism. They are bottled and have an extensive sale on the Pacific coast.

James K. Crook.

BASEDOW'S DISEASE. See *Exophthalmic Goitre.*

BASIL L.—(fam. *Labiatæ.*) *Ocimum Basilicum* L., the common garden basil, is an annual Asiatic mint, cultivated in kitchen gardens in Europe and America. It is from 30 to 50 cm. high, with branched quadrangular stems, and ovate or oblong serrated leaves. The flowers are usually in clusters of six, with an irregular calyx, having the upper lobe large, ovate, and decurrent. The corolla tube is very short; the stamens four, and declined. In fruit the calyx is reflexed. The plant has a mint-like and agreeable odor. The drug consists of the dried herb, and consequently answers to the above description. It contains about one and a half per cent. of *essential oil,* consisting mostly of a stearoptene, basil camphor, which readily crystallizes in the oil upon standing in the cold.

The use of basil is culinary rather than medicinal; it has the carminative qualities of the order, and may be used for the same general purposes. Its chief use is as a flavor. Dose of an infusion, *ad libitum;* of the oil, from 2 to 5 dgm. (0.2 to 0.5 gm. = ♏. iij. to viij.).

W. P. Bolles.

BASSIA OIL. See *Palm Oil.*

BATH, ENGLAND.—A town of 53,761 inhabitants, beautifully situated in the valley of the Avon, on the slopes of surrounding hills, one hundred and seven miles southwest from London. Bath has been a town of much reputation for its thermal springs ever since the days of the Roman occupation, and extensive Roman remains still exist there. Throughout English literature frequent mention is made of Bath, and it has had various vicissitudes of fortune; having been at one time one of the most fashionable watering places of England, and then degenerating into a quiet and somewhat neglected residential town for retired and invalided officials. Quite recently, however, the reputation of the place has again been rising. Owing to its sheltered position, being surrounded by hills, Bath affords an excellent winter residence, and a course of treatment can be taken at any season of the year; although May, September, and October are considered the best months.

The following meteorological data are taken from "Climates and Baths of Great Britain," 1895, to which the writer is indebted for the facts contained in this article:

OBSERVATIONS FOR 20 YEARS (1866–1885). (FAHRENHEIT SCALE.)

Seasons.	Mean.	Highest.	Lowest.	Range.
Spring	48.4°	51.2°	45.8°	5.4°
Summer	60.3	63.5	58.1	5.4
Autumn	50.7	52.3	48.5	3.8
Winter	41.4	46.3	36.4	9.9

Thirteen out of twenty winters had a mean temperature above 40° F. The mean annual rainfall was 32+ inches. Autumn is the wettest, and spring the driest season. The thermal waters are derived from three springs: the Hot Bath, of 120° F.; the King's Bath, of 117° F.; and the Cross Bath, of 104° F. They are the hottest baths of any in Great Britain, those of Buxton coming next. The waters come under the head of "simple thermal," and the analysis, according to Mr. Attfield, is as follows:

ONE IMPERIAL GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	7.85
Calcium sulphate	94.11
Calcium nitrate	.56
Magnesium carbonate	.56
Magnesium chloride	15.24
Sodium chloride	15.19
Sodium sulphate	23.16
Potassium sulphate	6.70
Ammonium nitrate	1.06
Ferrous carbonate	1.22
Silica carbonate	2.71
Total	168.36

Traces of rubidium, lithium, and strontium.

	Dissolved gas per imp. pints.
Oxygen	0.74
Nitrogen	4.60

There are various establishments for the application of these waters: (1) The King's and Queen's Public and Private Baths adjoining the Grand Pump Room; and adjoining the King's Bath is the Roman Bath. (2) The Royal Private and Hot Baths. The hot bath here is an open one holding 7,570 gallons. (3) The New Royal Private and Swimming Baths attached to the Grand Pump Room Hotel. (4) The Cross Bath, a cheap public one. All these establishments belong to the corporation of Bath.

In connection with these baths provisions are made for giving the "massage douches" like those at Aix-les-Bains, reclining douche baths, Berthollet's local vapor baths, the "Scottish douche," sitz baths, and various sprays and pulverizations for nasal and faucial troubles. There is also the umbrella spray chamber wherein strong but thin streams of hot mineral water play upon a metallic dome and are pulverized. The room in consequence becomes filled with a sort of mist, and is used for patients suffering from chronic catarrh of the respiratory passages. There are also swimming baths of various temperatures.

Originally the general method of using the waters externally was by immersion in deep cisterns, the patient standing in them covered with water up to his neck. Covered in this fashion he could move about to promote flexibility of the joints. These immersion baths are still in vogue, the temperature varying from 98° to 104° F. There are other baths arranged for patients in a reclining instead of an erect position, and also arrangements whereby helpless patients can be lowered into the water, like the impotent man at the pool of Bethesda. A fountain in the Grand Pump Room supplies water for drinking, the amount usually drunk being from four ounces to half a pint twice a day.

"Special virtue is claimed for the Bath treatment in diseases which involve the articular structures (chronic rheumatism), and sufferers from such diseases constitute a very large proportion of the patients who seek relief at Bath." In gout and gouty affections the Bath treatment

appears to be especially efficacious. In anæmia, neuralgia, and many diseases of the skin it is of undoubted value. It is also used in various other maladies, as those of the digestive, respiratory, and nervous systems. It is contraindicated in all acute diseases with high temperature, in pulmonary affections, in tuberculous affections of the joints, and in heart disease.

The accommodations are abundant, varied, and good.

From a personal visit the writer can attest to the attractiveness of Bath as a place of temporary residence; its situation, as has been said, is beautiful, and the city itself, with its crescents and terraces, its abbey church and its fine Victoria Park, and all its interesting history, has much to divert one. There are also pleasant excursions in the neighborhood. *Edward O. Otis.*

BATH ALUM SPRINGS.—Bath County, Virginia.

POST-OFFICE.—Bath Alum. Hotel and cottages.

This resort is situated midway between Millboro on the main line and Hot Springs on the valley branch of the Chesapeake and Ohio Railroad, being ten miles from either point. The location is at the base of Worm Springs Mountain in a rugged, broken section of country. The weather during the season from May to November is characteristically clear, bracing, and delightful, with few disagreeable days. The springs are five in number. We present the following analysis of Spring No. 2, which is fairly representative of the group, by Prof. W. H. Taylor:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium sulphate	1.13
Calcium sulphate	1.71
Lithium sulphate	Trace.
Magnesium sulphate	.46
Potassium sulphate	.34
Aluminum sulphate	29.99
Ammonium sulphate	Trace.
Manganese sulphate	.03
Iron persulphate	28.78
Sodium chloride	.11
Silica	1.95
Sulphuric acid	2.88
Total	65.38

Spring No. 1 contains 4.65 cubic inches of carbonic acid gas per United States gallon.

It will be seen that the waters are strongly aluminous and chalybeate with a fair proportion of free acid. They are astringent and tonic in their effects. Thus they have been found useful in chronic disorders and relaxed conditions of the mucous membranes, in skin diseases, and in general debility. *J. K. Crook.*

BATTEY'S OPERATION. See *Ovariotomy.*

BAYACURU.—The root of *Statice Brasiliensis* Boiss. (fam. *Plumbaginaceæ*), a seashore plant of the southern Atlantic. Containing twelve and one-half per cent. of tannin, this is a valuable astringent. There is no good authority for its use in other directions.

H. H. Rusby.

BAYBERRY.—*Candleberry. Wax Myrtle.* These names and various aboriginal and foreign equivalents are applied to various species of the peculiar genus *Myrica* (fam. *Myricaceæ*), but especially to the *M. cerifera* L., a very abundant, medium-sized shrub growing on and near the Atlantic coast of the United States. Its leaves are strongly and very pleasantly fragrant, and have been used for their aromatic stimulant properties. The bark contains a considerable percentage of tannin, as well as a small amount of the volatile oil, some resin, and an amaroid. It has been considerably used in ♏ xxx. doses as an astringent and tonic and also locally for its astringent effects. The fruits are thickly coated with wax, so as to impart a conspicuous bluish-white color to them, and, through their abundance, to the entire plant when in the leafless state. This wax has been removed and has found its way more or less into commerce.

H. H. Rusby.

BAY LEAVES.—Under this name three distinct leaves have come to be known. One of them, the Cherry Laurel—*Prunus Lauro-Cerasus* L. (fam. *Rosaceæ*)—is to be regarded quite as a spurious article, with composition (yielding prussic acid) and properties quite distinct. These leaves are about six inches long, sharply serrate, have one or more pairs of depressed glands near the stem on the under side, yield the bitter-almond odor when macerated, and have the same taste. Both of the others properly bear the name, and they agree closely in composition and properties. The Royal Bay, or European laurel, is the leaf of *Laurus nobilis* L. (fam. *Lauraceæ*). It is usually less than four inches in length, oblong, acute at both ends, obtusish, very thick, pale green, entire, but with the margin peculiarly crisped or wavy at right angles with the surface. It lacks the large basal glands of the last, as well as its bitter-almond odor and taste. This is the leaf usually used as bay in cooking. The third, our official bay leaf, or wild clove leaf, is from *Myrcia acris* D.C. (fam. *Myrtaceæ*), and yields the oil a description of which follows. These leaves, about as long as the last, are twice as broad. They are of a dark green or brown, somewhat glossy, rather thin, and have very numerous, fine, straight parallel secondary veins.

H. H. Rusby.

BAY, OIL OF.—OLEUM MYRCIÆ. "A volatile oil distilled from the leaves of *Myrcia acris* D.C. (fam. *Myrtaceæ*)" (U. S. P.).

The oil is usually distilled in the West Indies, and imported into the United States in bottles, although of late an increasing quantity has been distilled from the dried leaves, imported here. The oil thus obtained is not quite so bright and fragrant as the best imported, but is much better than the common grades. Oil of bay is thus described in the Pharmacopœia: "It is a brownish or dark brown liquid, of an aromatic, somewhat clove-like odor, a pungent, spicy taste, and a slightly acid reaction. Specific gravity about 0.975 to 0.990." It is a mixture of light hydrocarbons with *eugenol* (see *Cloves*).

Its medicinal qualities are those of the stimulating oils in general (allspice, cajuput, cloves, etc.), but it is only employed as a grateful perfume. Bay rum, which is the form in which it is generally used, was originally made by distilling rum from the fresh leaves and branches. But this imported perfume is now generally substituted by a simple solution of the oil in cologne spirit or alcohol, flavored or not according to the taste of the manufacturer. As it is considerably used about the sick, a formula is furnished by the Pharmacopœia, as follows: "Spiritus Myrciæ, oil of myrcia, 16 parts; oil of orange peel, 1 part; oil of pimento, 1 part; alcohol, 1,220 parts; water, a sufficient quantity." *W. P. Bolles.*

B. B. MINERAL SPRINGS.—Pike County, Missouri.

POST-OFFICE.—Bowling Green. Hotels, etc., in Bowling Green.

ACCESS.—Viâ Chicago and Alton and St. Louis and Hillsborough Railroad to Bowling Green.

These springs are two in number. They do not appear to be used extensively as a resort, but their waters are widely sold in the Western States. The following analysis was made in 1887 by Dr. P. Schweitzer, Professor of Chemistry in the Missouri State University:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Magnesium sulphate	669.47
Sodium sulphate	61.04
Calcium sulphate	80.17
Aluminum sulphate	18.31
Silica	2.66
Lithium chloride	.29
Total	831.94

This is a very strong sulphated-saline water, with excellent purgative properties, containing, as it does, the sulphates of both magnesia and soda. As a laxative it is recommended in wineglassful doses at bedtime, the stomach being empty. It is said to possess tonic effects

when taken in wineglassful doses or less after each meal. When heated and used for bathing it is valuable in rheumatism. *James K. Crook.*

BDELLIUM.—The bdelliums, for there are two varieties, are gum resins of the frankincense type, from at least two, probably several species of *Balsamea*. The East Indian bdellium is reputed to come from *Balsamea* (*Balsamodendron*) *Mukul* Engl.; that of Africa from *B. africana* Engl. (fam. *Burseraceæ*). The latter is the variety official in France; neither is so in any other country.

Bdellium resembles myrrh in appearance and qualities. It is in small yellowish or reddish-brown tears, or sometimes in larger masses; transparent, fragrant, brittle. It softens between the teeth, and crackles in the flame. The odor and taste resemble those of myrrh, but are weaker. It contains about sixty per cent. of *resin*, between thirty and forty of *gums*, mostly bassorin, and one or two of *volatile oil*.

Bdellium is a mild local stimulant like myrrh, of which it is almost an exact duplicate, though inferior. It is sometimes used as an adulterant of myrrh. It is now and then used in Europe in plasters. *W. P. Bolles.*

BEALL SPRING.—Warren County, Georgia. Hotels and cottages.

ACCESS.—Viâ Macon and Augusta Railroad to Warrenton, thence by hack line to springs. Location eight miles south of Warrenton. This spring was discovered in the early part of the present century, and some rude improvements were made as far back as 1825. The following qualitative analysis gives the principal ingredients of the water:

Solids.	*Solids.*
Calcium carbonate.	Potassium sulphate.
Potassium carbonate.	Magnesium sulphate (trace).
Iron carbonate.	Silica.
Sodium carbonate.	Organic matter combined with sulphur.

Gases: Hydrogen sulphide, small quantity: carbonic anhydride.

Sulphureted hydrogen may be considered the most important ingredient. The combination of ingredients gives the waters many of the advantages of three prominent classes of spring waters, viz., the sulphureted, the chalybeate, and the calcic waters. The flow of water is about one gallon per minute. The spring is located on an eminence, and is surrounded by a fine grove. The improvements are not extensive, consisting of a small hotel and a few cottages. *J. K. C.*

BEARBERRY.—UVA URSI. "The leaves of *Arctostaphylos Uva Ursi* (L.) Sprengel (fam. *Ericaceæ*)." (U. S. P.).

This little gregarious, evergreen shrub, with reclining or creeping stems, and stiff, shining, green leaves, is at home on the dry hills and plains, as well as sandy barrens near the coast, in the colder parts of the entire north temperate zone.

The leaves, the part used, are nearly sessile, about 2 cm. (four-fifths inch) in length; narrowly obovate or spatulate, with entire, slightly revolute margins. They are very thick, dark green, and shining above, pale green underneath. The dried leaves preserve their color well; they have a faint, herby, or tea-like smell, and a not unpleasant bitterish-astringent taste.

Uva ursi contains both *tannic* and *gallic acids*—the former in large quantity; also *ericolin*, to which part of its bitterness is due, *urson*, *arbutin* and *methyl arbutin*. (For the characters and properties of these substances see *Ericaceæ*.)

Uva ursi has the mildly stimulating and antiseptic diuretic action of arbutin, and is rather extensively used.

Dose of uva ursi, from 2 to 4 gm. (ʒ ss. to i.), or more if the digestive organs are not disturbed by it. There is an official fluid extract, as well as an extract, but the decoction is probably a better form of administration. Arbutin is frequently used instead, in Bright's disease, in doses of 0.15 to 0.5 gm. (gr. iss. to viij.).

Arctostaphylos glauca, a West American species, with larger roundish leaves, has similar qualities, and also contains *arbutin*. *H. H. Rusby.*

BEARSFOOT.—The root of *Polymnia Uvedalia* L., (fam. *Compositæ*), a very coarse perennial herb, common through most of the United States. The alterative properties claimed for it are of the most vague character, and we have no good authority for its use.
H. H. Rusby.

BECK'S HOT SULPHUR SPRINGS.—Salt Lake County, Utah.

POST-OFFICE.—Salt Lake City. Hotel.

This is a well-known pleasure and health resort of Salt Lake City. It is fitted with a sanitarium, bath-houses, swimming pool, hotel, restaurant, etc. The water has a natural temperature of 128° F. The following analysis was made by Professor Hirsching, of the Salt Lake Mining Academy:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	14.63
Sodium sulphate	140.96
Magnesium sulphate	26.87
Potassium sulphate	10.61
Sodium chloride	598.33
Potassium chloride	8.45
Magnesium chloride	7.28
Calcium chloride	6.32
Calcium carbonate	23.61
Magnesium carbonate	5.88
Iron carbonate	.46
Sodium borate	.23
Calcium borate	.12
Silica	1.23
Undetermined	3.67
Total	848.85

Sulphureted hydrogen gas, large quantities; carbonic acid gas, large quantities.

In the author's work on "Mineral Waters" this is classified as a muriated and sulphated saline. Although heavily mineralized, it is perfectly clear, and when taken cold is entirely palatable. It has a diuretic and cathartic influence when used internally. The baths here are said to be highly efficacious in chronic metallic poisoning, tertiary syphilis, obstinate rheumatism, gout, and skin affections. *James K. Crook.*

BEDFORD ALUM, IRON, AND LITHIA SPRINGS.—Campbell County, Virginia.

POST-OFFICE.—Bedford Springs. Hotel.

ACCESS.—Viâ Norfolk and Western Railroad to Forest Depot, thence four miles by private conveyance to springs. Also viâ Virginia Midland Railroad to Lawyer's Depot, thence four miles by carriage to springs.

These springs are located within a few hundred yards of Bedford Village, one of the ancient historic spots of the Old Dominion, still redolent with memories of Patrick Henry, John Randolph of Roanoke, Thomas Jefferson, and other great Virginians of bygone days. The healthy nature of the location is attested by the longevity of the inhabitants, persons of threescore and ten and over being almost a rule instead of a rare exception. The landscapes about the springs are of great beauty and interest. The peaks of Otter, twenty miles distant, may be seen raising their lofty crests to an altitude of four thousand feet above the sea. The Natural Bridge is not far distant, and Lynchburg, a city of 20,000 inhabitants, is within ten miles. The location of the springs is about thirteen hundred feet above the sea level, and the average summer temperature is 66° F. The following analysis of the water was made in 1877 by Prof. M. B. Hardin, of the Virginia Military Institute:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Copper sulphate	.06
Iron protosulphate (ferrous)	.59
Iron persulphate (ferric)	19.26
Aluminum sulphate	24.18

Solids.	Grains.
Manganese sulphate	.19
Zinc sulphate	.07
Nickel sulphate	.04
Cobalt sulphate	.07
Calcium sulphate	4.99
Magnesium sulphate	12.58
Potassium sulphate	.71
Sodium sulphate	.87
Lithium sulphate	.24
Sulphuric acid	4.01
Silica	1.69
Calcium phosphate	.30
Magnesium nitrate	.26
Ammonium nitrate	.24
Sodium chloride	.20
Calcium fluoride	Trace.
Organic matter	.29
Total	70.84
Gases.	**Cubic in.**
Carbonic acid	6.98
Oxygen	1.32
Nitrogen	3.33
Total	11.63

Temperature of water, 48° to 56° F.

This water is an acid chalybeate with aluminous properties. The effects of the water are tonic, alterative, diuretic, and somewhat astringent. In small doses internally it has been found useful in diarrhœal disorders. In larger quantities it has an aperient effect. It is used in a wide range of diseased conditions. The spring water as well as the evaporated residue (the "Bedford Mass") is used commercially and forwarded to any point desired. An excellent hotel is maintained at the springs.

James K. Crook.

BEDFORD SPRINGS.—Trimble County, Kentucky.

POST-OFFICE.—Bedford Springs. Hotel and cottages.

ACCESS.—Viâ Louisville and Cincinnati Short-line Railroad to Sulphur Station, thirty-six miles east of Louisville and seventy-one miles west of Cincinnati, thence six miles by pike road to springs.

These springs are located on a high ridge between the Ohio and Little Kentucky rivers. They are three in number, and yield about three gallons of water per minute. The following qualitative analysis was made by J. P. Barnum, analytical chemist:

Sodium chloride.	Sodium sulphate.
Magnesium bicarbonate.	Lithium carbonate.
Calcium bicarbonate.	Sodium carbonate.

Reaction, alkaline to test paper.

The water is recommended for diseases of the stomach, kidneys, and liver, and in gout and rheumatism. It is sold in Louisville by the gallon or barrel.

J. K. C.

BEDFORD SPRINGS.—Bedford County, Pennsylvania.

POST-OFFICE.—Bedford. Hotel.

ACCESS.—The Baltimore and Ohio Railroad transfers passengers at Cumberland, Md., and the Pennsylvania Railroad at Huntingdon, Pa.

The Huntingdon and Broad Top Railroad connects with Pennsylvania Railroad trains from the East and West, and runs an express train of parlor cars through to Bedford without stop.

The Bedford Mineral Springs have their source in a beautiful valley on the eastern slope of the Allegheny Mountains, at an elevation of ten hundred and eighty feet above tide water. The location is one mile and a half south of the old historic town of Bedford, the county seat of Bedford County, in a region noted for its pure, invigorating air, salubrious climate, and beautiful and varied scenery. The medicinal virtues of the springs were known as early as the year 1804.

Since those early days the resort has maintained a steady popularity with the tourist, pleasure-seeker, and invalid, and it may to-day be ranked among the best of the many excellent summer watering places which the country affords. In addition to the numerous attractions of climate, scenery, etc., the visitor will find a very comfortable modern hotel, well equipped with the most recent improvements. A good orchestra is maintained during the season. The magnesia spring has been mainly instrumental in giving the place its reputation. It issues from an opening in the rock, about three feet in length and eighteen inches in width, and flows about two thousand gallons of water per hour, without interruption or intermission, the year round. A recent examination of the hitherto somewhat neglected Bowling Alley Spring shows it to be quite as strong in magnesium salts, while carrying less lime. We present analyses of these two springs, made in 1895 by Victor G. Bloede, analytical chemist, of Baltimore:

MAGNESIA SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium carbonate	2.04
Sodium chloride	.72
Magnesium sulphate	32.54
Magnesium carbonate	6.06
Potassium carbonate	.38
Calcium sulphate	107.80
Lithium chloride	.32
Silica	.25
Iron oxide	.05
Alumina	.11
Ammonia	.02
Nitrates and nitrites	None.
Total	150.29
Free carbonic acid	1.85
Water of crystallization and volatile matter	36.41
Total	188.55

BOWLING ALLEY SPRING.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium bicarbonate	9.70
Sodium chloride	1.12
Magnesium sulphate	32.96
Magnesium carbonate	5.23
Calcium sulphate	83.20
Silica	1.10
Iron oxide	.04
Alumina	.09
Nitrates and nitrites	None.
Ammonia	Trace.
Total	133.44
Free carbonic acid	2.17
Water of crystallization and volatile matter	37.74
Total	173.35

These analyses show very potent waters of the sulphated-saline and calcic variety. They are laxative in small doses, purgative in larger. Furthermore, they have a considerable diuretic influence, and each contains sufficient iron to counteract the debilitating tendencies often met with in waters of this character. The Magnesia Spring contains also a small amount of the chloride of lithium, which serves to widen the sphere of its probable utility. The Bowling Alley Spring is quite freely charged with that ever-valuable ingredient of saline waters, the carbonate of sodium, which renders it very useful as an antacid and antifermentative, in addition to its cathartic properties. These waters may be counted upon to render good service in flatulent dyspepsia, functional disturbances of the liver, abdominal engorgement, and chronic constipation. They are also highly recommended by many well-known physicians for gouty and rheumatic disorders. They are used commercially. There are several other valuable springs in the neighborhood.

BEDFORD CHALYBEATE SPRING, BEDFORD COUNTY, PA.

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	8.85
Magnesium carbonate	1.20
Iron carbonate	.44
Magnesium carbonate	Trace.
Sodium carbonate	.39

Solids.	Grains.
Potassium carbonate	.13
Calcium sulphate	2.74
Calcium phosphate	.03
Sodium chloride	.12
Hydrogen sulphide	Trace.
Silicic acid	.79
Carbonic acid (free)	5.60
Total	20.29

The physiological action of this water tends to increase the appetite, promote the digestion of food, and improve the quality of the blood. The predominance of the calcareous salts would seem to give the water an astringent and constipating influence. These effects, however, have not been observed by those who have used it freely. It has, in fact, seemed to exert a mild laxative action, and is furthermore quite an efficient diuretic. Its action resembles that of the well-known Bocklet Springs, near Kissingen, in Bavaria. The water is useful in cases of anæmia, general debility, and amenorrhœa, and in convalescence from acute diseases. This water and the residual salts obtained by evaporation are used commercially; an extract and an ointment are prepared from the latter.

James K. Crook.

BED-SORES (Decubitus; Gangræna per Decubitum), a term applied to gangrene of the skin and underlying soft structures, resulting from pressure of the body upon an object, usually the bed, in long-continued recumbency. The situations in which bed-sores are most frequently seen are over the tuberosities of the ischium, over the sacrum, the scapulæ, the spinal column, the great trochanters, the tuberosity of the os calcis, and in other portions of the body which may have received continuous pressure. Sometimes they are the result of the pressure against each other of contiguous surfaces of integument. They are rarely seen upon the anterior surface of the body, unless the patient has been lying for a long time in the prone position.

Bed-sores are described as being both acute and chronic. The acute form (Charcot) is met with in injury or disease of the spinal or cerebral nervous centres. It appears oftentimes in a few hours after lesions of these parts, and although it comes in portions of the body undergoing pressure, the rapidity of its establishment suggests that other than merely local causes are factors in its production. The chronic form appears at any time after a patient has been lying in bed for a long while.

The manner in which these bed-sores commence varies with the disease or injury which they complicate. Three different methods of formation, at least, are easily recognized: (1) By an erythematous reddening of the skin, especially if the part has been irritated by urine or fæces; (2) by a primary necrosis of the skin, seen in weak individuals; (3) by a phlegmonous inflammation, with the formation of pus and undermining of the tissues.

Whatever may have been the method of formation, the issue in all is the same; as much of the integument as has been compromised sloughs; the sloughs are cast off in shreds or as a whole; there remains an ulcer, oftentimes weak and indolent, with sloping edges, and without any tendency to heal. At times the sloughing does not stop at the integument, but all of the soft parts, and even bony structures, become involved in the necrotic process, leaving a lesion revolting in appearance and disgusting in odor.

Etiology.—In the causation of bed-sores pressure plays the most important rôle, as noted above. Those situations which are subjected to the most continuous pressure are the most frequently affected, and especially those parts which immediately cover bone. Over such places the skin is pressed close against the unyielding bone, the blood-vessels of the part are closed by the pressure, the nourishment of the part becomes imperfect or ceases completely, and as a result sloughing takes place. There are certain predisposing causes, however, which hasten the development of bed-sores. These predisposing causes are: (1) any circumstance which lowers the vitality of a part or of the whole body; (2) the presence of fluids or substances which irritate the skin; (3) diseases or injuries which prevent movement of the patient's body; (4) trophic disturbances (?).

In the first class of causes are included different forms of diseases, as typhus and typhoid fever, phthisis, scurvy, and any long-continued disease.

Of the fluids and substances which irritate the integument, urine and fæces are the most common, either passed in bed involuntarily in cases of spinal trouble, or voluntarily when the patient's morale is lowered. Particles of food, and larger substances, sometimes contribute to the irritation when the patient does not receive proper attention.

The diseases and injuries which prevent movement of the patient's body are all those which cause hemiplegia or paraplegia; in these cases voluntary motion is lost, and in many cases movement of the body by attendants is extremely painful, so that, of necessity, the same position is assumed almost continuously by the patient.

The question of the rôle played by trophic nerves in the causation of bed-sores cannot be satisfactorily discussed, as their presence in the human body has not been proven. The rapidity with which the skin sloughs in injuries of the central nervous system (acute bed-sore of Charcot) makes it evident that nutritive changes have taken place in such parts, which can be explained only by assuming that the nervous power controlling the nutrition of the part has been lost as an effect of the central lesion. This view is substantiated by the tegumentary lesions seen in cases of dementia paralytica (Shaw: St. Barth. Hosp. Rep., vol. xiii., 1878, pp. 130–133) in the last stages. In these cases so-called bed-sores appear, *i.e.*, superficial sloughing of the skin on both the anterior and posterior surfaces of the body, and without reference to the portions of the body pressed upon.

Symptoms.—Bed-sores so frequently occur in patients in whom the sensibility is blunted or lost that subjective symptoms are wanting, and the presence of the sore is only determined, often accidentally, by the attendant. The patient under such circumstances appreciates nothing even though the sloughing of the soft parts be of great extent. In some instances, however, when the sensibility of the parts has not been greatly impaired, the patient experiences itching or burning sensations, with sometimes pains lancinating through the parts affected, the pain at times being severe enough to necessitate the use of anodynes to quiet it. The local symptoms of a bed-sore are those attending gangrene of the skin and soft parts.

It is impossible to estimate how much the general system is affected by bed-sores. It is evident that extensive loss of tissue, from gangrene and suppuration, must have a marked effect in depressing the vital forces, and under such circumstances death has been known to occur either from pyæmic exhaustion or from the involvement of important organs in the sloughing process.

Treatment.—Prevention is the cardinal rule to be observed in the treatment of bed-sores. To carry this rule out successfully, it is necessary to recognize the circumstances under which bed-sores appear, to know the diseases which they most frequently complicate, and, being fully aware of their readiness to appear in such diseases, to combat their appearance by constant care and appropriate treatment. In the large majority of cases, bed-sores result from the neglect of this prophylactic treatment. So well is this fact recognized that in the large hospitals, where the care of the sick is entrusted to trained attendants, it is considered a matter of personal reproach if a patient contract bed-sores, and it is difficult to dissipate the impression that they are not the result of negligence.

This preventive treatment, which is frequently not easy to carry out, consists in:

1. Relieving the pressure to which the parts are subjected.
2. The keeping of these parts clean.
3. The use of chemicals to harden the integuments.

The relief of pressure is, perhaps, the most important of all in the treatment of bed-sores, for in this way the

engorgement or the anæmia of the vessels of a part is relieved. This can be accomplished by getting the patient to change his position in bed from the back to one side or the other. If a patient's mind be dulled by disease, so that he has no desire to move, or if some injury to the spinal cord has occurred, so that the lower portion of the trunk and lower extremities are paralyzed, and not only is voluntary movement impossible, but artificial movement very painful, the difficulties in the treatment of the case are much increased.

The patient usually lies upon the back, and cannot be made to assume any other position. The pressure soon becomes continuous, as relief cannot now be afforded by a change of position, and the weight must be taken off these parts by appliances so arranged as to distribute the pressure upon other parts of the body. This can be accomplished by the use of pillows, rings, or air cushions.

The ordinary air cushion, made in the form of a ring with an aperture in the middle, is of especial service, and is so adjusted that the part from which the pressure is to be relieved falls over the opening in the ring. If no air cushion can be obtained, a ring can be made out of oakum, jute, or cotton, which will serve the purpose, although not so well.

Water-beds are of great assistance in the preventive treatment of bed-sores, because they adjust themselves to the irregularities of the body, and distribute the pressure evenly over its entire surface. In case such a bed cannot be procured, great pains must be taken to see that the bed used is suitable. It must be springy, but still hard enough to prevent hollows and irregularities where the patient lies. The bed-clothes must be perfectly smoothed out, no wrinkles must appear in the sheet on which the individual lies, and an important point is to see that no foreign bodies, as, for example, food, fall into the bed and get under the patient. Cleanliness is a very important factor in the treatment. Especially is it necessary when there is incontinence of either fæces or urine, or both. Either of these discharges is irritating to the skin, and may set up inflammations which are readily converted into bed-sores. There are beds constructed in such a manner that the portion under the genitals can be removed, so that a more or less complete vent for the discharges is afforded; but the best of these appliances are of very restricted value, and only constant care and watchfulness can prevent the patient from being bathed in these inflammation-causing discharges.

Of the medicines which are used to harden the skin, alcohol is the most useful, combined with some astringent, as tannic acid, lead, or zinc. Bathing the parts several times a day with a preparation of this kind often gives a healthy tone to their circulation, and averts the formation of a bed-sore. *William L. Wardwell.*

BEECH DROPS. See *Cancer Root.*

BELKNAP HOT MEDICAL SPRINGS.—Lane County, Oregon.

Post-Office.—Belknap Springs. Hotel and camping grounds.

Access.—Viâ Southern Pacific Railroad to Eugene, one hundred and twenty-five miles south of Portland; thence sixty miles east by stage to springs.

The location of these springs is in the heart of the Cascade Mountains, two thousand feet above the sea level. This is a very fine and picturesque region, and it presents many attractions to the tourist and invalid. The climate is equable, the weather during the summer months being generally clear and pleasant, with cooling winds.

The average summer temperature is 65° F., while it is stated that the average winter range is but twenty degrees lower. The McKenzie River, near by, is famous for its magnificent trout; and deer and other game abound in this region. There is only one spring, but it yields about twelve thousand five hundred gallons per hour. The temperature of the water is 188° F. The following analysis was made in 1894 by Prof. G. W. Shaw, of the Oregon State Agricultural College, at Corvallis:

One United States Gallon Contains:

Solids.	Grains.
Calcium phosphate	13.91
Calcium chloride	62.20
Potassium chloride	7.68
Magnesium chloride	2.90
Sodium chloride	53.93
Manganese chloride	Traces.
Silica	4.72
Iron and alumina	.17
Total	145.51

The bathing facilities comprise medicated, steam, electric, and shower baths, hot or cold, with massage. A large swimming tank is an attractive feature. The baths are attracting considerable attention in the treatment of rheumatism, syphilis, and skin diseases.

J. K. C.

BELLADONNA.—*Deadly Nightshade.* "*Black Cherry.*" (For a description of the belladonna plant, see article on *Poisonous Plants.*) The belladonna plant yields two official medicinal articles, namely, *Belladonnæ Folia*, "the leaves," and *Belladonnæ Radix*, "the root of *Atropa Belladonna* L. (fam. *Solanaceæ*)."

Belladonna is a native of Europe and adjacent Asia, where the drug is mostly collected from wild plants. In Europe it is also largely cultivated for medicinal purposes. It has become naturalized to a slight extent in the United States. The composition of leaf and root is very similar, the difference being rather in the greater quantitative irregularity of the leaves than in kind. The leaves do, however, contain a rank-smelling principle not present in the root, rendering them objectionable for some purposes, but possibly of greater therapeutic value. They contain also considerable chlorophyll, which enables their extract to impart an objectionable green stain to clothing, when used in plasters. Both articles may be regarded as exceptionally irregular and uncertain in quality. Some of the causes of this irregularity are not known, so that no methods of physical examination of the drug can eliminate them, a chemical assay being requisite. Others are known and can be detected by careful examination. The leaves are said to be adulterated with those of various other plants, but an examination of many samples by the writer has failed to confirm the statement. Those of henbane, digitalis, and verbascum are all hairy, while belladonna is smooth; those of henbane and potato are toothed or lobed, while the margin of belladonna is entire. The leaves of datura, or stramonium, come in a crumpled mass, closely resembling that of belladonna leaf, and one is often mistaken, upon superficial examination, for the other. The belladonna mass is, however, almost invariably of a brownish-green color, a bright green indicating an immature leaf, while that of stramonium is of a clear, usually a dark, green color. Upon soaking and flattening out a leaf, the large, angular teeth or lobes of the latter, with their very unequal base, contrast strongly with the entire margin, regular outline, and nearly equal base of the former. It is probably quite safe to state that the irregular composition and strength of the leaves are due not to adulteration, but chiefly to different stages of maturity when collected and to the varying care taken in preparing and preserving them, conditions which it is very difficult, even if possible, to determine in the drug other than chemically or physiologically. As to the roots, they are greatly subject to substitution, adulteration, and imperfection of quality, which are much more readily detected by physical inspection than is the case with the leaves. Scopolia is very largely substituted for belladonna, especially in Europe. As the two drugs present not the slightest similarity, this action can be regarded only as wilful and deliberate, as is the addition of the roots of burdock, medicago, and of one which appears to be wild, unpeeled marshmallow. The two last named are flexible, while belladonna is stiff and brittle. Burdock has a soft pith or a hollow centre. The three last-men-

tioned forms of adulteration are highly objectionable, as the articles have no properties at all like those of belladonna. Scopolia is a rhizome, composed of joints, each bearing upon its upper surface a conspicuous circular scar a quarter inch or more in diameter. Its composition and properties are very similar to those of belladonna, a fact which soothes the consciences of those who engage in this form of substitution. The imperfection of genuine belladonna root, aside from obviously bad conditions of mould and worminess, relate to its being too young (when less than two-fifths inch in thickness) or old, thick, and woody. The active constituent resides chiefly in the bark; hence old thick pieces, in which the increase of weight is chiefly of inert woody fibre, must be inferior. The two drugs are described as follows:

The Leaves.—From 10 to 15 cm. (4 to 6 inches) long and about half as broad, ovate, abruptly and almost equally narrowed into a petiole of extremely variable length, the apex acute or acutish, but not acuminate or tapering, entire on the margin, smooth, thin, drying brownish green, the upper surface browner, the lower greener and paler, both surfaces minutely whitish punctate; odor slight; taste bitterish, somewhat acrid.

The Root.—In cylindrical, but slightly tapering, coarsely wrinkled pieces, bearing their bark, rarely exceeding 15 cm. (6 inches) in length, having a thickness of 10 mm. (two-fifths inch) to 25 mm. (1 inch), often split; externally of a light brownish gray, much subject to abrasion, which reveals a lighter inner layer, internally whitish; breaking with the characteristic emission of a puff of dust, and exhibiting a nearly smooth and starchy fracture, indistinctly many-radiate near the bark; nearly inodorous; taste sweetish, afterward bitterish and strongly acrid. Portions of the stem and of thick, hard, woody crowns should not be included.

Composition.—The minor constituents of the leaves are starch, gum, wax, and asparagin; and of the roots, starch. The active constituents of both are the mydriatic alkaloids, about one-tenth to one-half per cent. in the leaves, one-fourth to three-fourths per cent. in the root. As regards the identity and precise relative amounts of the different alkaloids, discussion is in the present state of our knowledge unprofitable, and in view of their very similar therapeutic effects, equally unimportant. *Belladonnine* and *hyoscine* (if the latter be really present at all—see *Henbane*) are in such small amounts as to be absolutely unimportant. The only alkaloid other than *atropine* which is present in appreciable amount is *hyoscyamine*, and the action of this is so nearly identical with that of atropine as to render its presence of no importance. Theoretically, the relations of the two last named are of great interest. They are so closely similar that, even when in the pure condition, it is almost impossible to distinguish them. It is believed that very young roots will yield only hyoscyamine, old ones chiefly atropine. It is not by any means certain, however, that the extraction of one proves that it so existed in the living plant. It is, further, very uncertain as to the maintenance of their identity when the respective alkaloids are taken into the stomach or the system. Certainly their practical effects are generally regarded as identical, so that therapeutic interest in the drug centres finally in its percenttage of total alkaloid. Since, according to the above showing, the preparations of belladonna must vary so widely, and as the determination of their strength is no longer difficult, none should ever be used whose percentage of total alkaloid is not known. It is altogether probable that the forthcoming edition of the Pharmacopœia will fix this percentage at thirty or thirty-five hundredths for the drug and its fluid extract, that of the other preparations in proportion to their relative strengths. In considering the properties of belladonna, then, we may restrict our attention to those of the alkaloid atropine.

Atropine or Atropina ($C_{17}H_{23}NO_3$).—"An alkaloid obtained from belladonna. As it occurs in commerce, it is always accompanied by a small proportion of hyoscyamine extracted along with it, from which it cannot be readily separated" (U. S. P.). It occurs in white, acicular crystals, or as a fine white powder, odorless, bitter, and acrid, becoming yellowish on exposure. It is soluble in water to the extent of nearly four grains to the ounce, and freely soluble in alcohol, as well as in fifty parts of glycerin. It readily forms salts. Chemically, it is a compound of the alkaloid tropine (which lacks the properties of atropine) and tropic acid. Hence alkalies, besides acting as precipitants, as in the case of other alkaloids, take away the tropic acid and convert the atropine into inactive tropine. Decomposition also occurs if it be heated with water or acids.

Action.—Atropine has no action upon the unbroken skin unless absorption occur. Its tendency to absorption is very slight, but can be increased by inunction or to an uncertain extent by application in the form of a plaster, for a continuous period, under the influence of the heat and confinement and the friction resulting from natural movements. Mixing it with glycerin or with alcohol or other volatile substance also leads to its absorption. It will then act both locally and systemically, and more or less poisonous symptoms can be thus induced. Its local action, applied thus or to a denuded surface, or injected into the tissues, is that of a paralyzant of the nerve endings, especially the sensory. When pain is present, this sensory depression is increased by the lessened irritation due to slightly decreased muscular movement. The systemic effects will be considered later. The local effects upon mucous membranes are also slightly benumbing, due to sensory paralysis, and inhibitory of the secretions, through paralysis of the nerve endings which excite them. The local effect in the eye is to paralyze the endings of the third nerve, thus allowing the iris to relax, producing wide dilatation of the pupil, and also to destroy the power of accommodation.

The direct systemic effects are entirely upon the nerve tissues, more upon the periphery than upon the centres. The central effects are, moreover, for the most part, rendered inoperative in the net practical results observed, because the peripheral actions are antagonistic to, and more than sufficient to overcome them. Of the centres, the highest are affected most and the lower successively less. The primary effects upon the centres are stimulant, the secondary depressant. The most prominent, therefore, is cerebral stimulation, excitement or delirium. Even in the mildest case, the stimulation can be seen to be of an intoxicant or uncontrolled character. The cardiac centres, both vagus and accelerator, are stimulated. The first result, through the vagus, is a slowing of the heart, which almost at once yields to a quickening, at first probably through the accelerator stimulation, afterward by the secondary depression of the vagus, and lastly, as a result of depressant action on the vagal endings. The vaso-motor centres are stimulated, with a brief rise of blood pressure; this is quickly overcome, chiefly by the peripheral effects, but partly by the secondary depression of the centres. Some claim also that the secondary dilatation of the vessels is due to direct stimulation of the dilator centres, but this action would probably be very brief. The respiratory centres are stimulated, with quicker and deeper breathing at first, followed by reverse conditions. The heat centres are stimulated, and there is a rise of temperature. As heat loss by evaporation of perspiration is wanting, this central action is not fully counteracted at the periphery, even though the superficial vessels are dilated; thus the rise of temperature is maintained.

The peripheral effects of atropine, for the most part, counteract and overcome the central. They are of a paralyzing nature, and relate both to movement and secretion. In regard to movement, inhibitory endings may be paralyzed so as to allow a result which is but apparent stimulation, as in the secondary quickening of the heart due to paralysis of the vagal ends, and the permission of an increase in peristalsis, due to paralysis of the splanchnic terminations. The latter action results in a laxative effect upon the bowels.

The same effect is produced upon the eye as results locally, as above described. All the buccal secretions

are checked, and the mouth and throat are made dry. The pancreatic secretion is similarly checked. The effect upon the production of respiratory mucus is the same as that upon the buccal, and the air passages become comparatively dry. Thus it may be sedative to respiratory irritation; but the effect is apt to be very transient. The same drying effect is produced upon the skin. The skin is red, however, from vascular dilatation, resulting from paralysis of the motor nerve endings in the arterial muscular fibres. This reddening is sufficient to produce a scarlatina-like flushing which has led to errors of diagnosis. Atropine has a strong tendency to dry up the milk.

Most of the therapeutic actions of belladonna are explained by the above pharmacodynamic deductions. Some, however, are still puzzling.

The local uses of belladonna are of almost as great importance as the internal. Prominent among them are the uses of atropine in the local treatment of the eye. The dilatation of the pupil by it permits of intra-ocular examination, checks iritic adhesions or breaks them down if formed, and checks ocular hernia. These results are accompanied by a lessening of pain and even a reduction of inflammation.

Many forms of superficial and some deeply seated pains, as rheumatism and neuralgia, are sometimes relieved by the belladonna plaster, or by the liniment well rubbed in, or by a solution in chloroform or camphor. Cardiac and respiratory pains are often relieved similarly. Toothache is often relieved by direct application of atropine to the nerve. Many forms of itching are promptly relieved and local inflammations scattered. Pain from hemorrhoids is partly relieved. The checking of the milk secretion can sometimes be produced by local application of the plaster. Application of a solution of atropine will often check local perspiration, though it is quite uncertain. In the nature of local applications may be regarded the intramuscular or deep injection of atropine, often combined with morphine, to relieve pain or spasms which cannot be modified by its superficial application. Inhalation of a spray containing atropine, for the relief of asthma, may also be regarded in the same light.

Internally, belladonna is probably more often used, in large doses, to check incontinence of urine, and as an adjunct of cathartics or laxatives, than for anything else. While it alone may act as a laxative, it is very uncertain. Continually used, especially together with nux vomica, it may overcome chronic constipation. Next in importance is its use in respiratory diseases, where it has a wide field of usefulness. In asthma, it often gives relief when nothing else will, and by varying its use with that of its related alkaloids permanent benefit may be secured. A similar benefit may result from its use in whooping-cough.

It checks excessive secretion, especially from the nose. With this result, irritable cough (of suitable causation) is greatly relieved. It is an excellent remedy for relieving the sweats of phthisis. Sore throat, unless of the excessively dry variety, is very favorably influenced. Cardiac inflammation or pain is benefited by its internal administration, as well as by local application. Belladonna is a useful antidote to poisoning by morphine.

The official preparations of belladonna leaves are the extract, of which the dose is 0.008 to 0.03 gm. (gr. $\frac{1}{8}$ to $\frac{1}{2}$) and the 15 per cent. tincture, dose 0.3 to 2.0 c.c. (♏ v. to xxx). Of the extract, there is a 10-per-cent. plaster and a 20-per-cent. ointment. Of the root there is a fluid extract, dose 0.06 to 0.2 c.c. (♏ i. to iij.), and of this we have a liniment, 95 parts with 5 parts of camphor. Children bear larger doses of atropine or belladonna, proportionally to their age, than adults.

Commercial belladonna plasters are usually made either from belladonna root, to overcome the disagreeable stain and odor of the leaf extract, or from the rhizome of scopolia. Probably the very great bulk of them are made from the latter. *H. H. Rusby.*

BELLADONNA. (TOX.) See *Atropic Poisons.*

BELL'S PALSY. See *Facial Paralysis.*

BENNÉ OIL.—Oleum Sesami; *Teel Oil.* "A fixed oil expressed from the seeds of *Sesamum Indicum* L. (fam. *Pedalineæ*)" (U. S. P.).

The benné plant is an erect, hairy annual, two to four feet high, supposed to have originated in Africa, but so long and so widely cultivated that knowledge of its nativity has been lost. It has been grown for its edible seeds, and for their oil, of which the yield is sixty or seventy per cent., and which is used as food and for many other purposes. The plant is grown to some extent in our Southern States. The oil is yellow or yellowish, inodorous, and of a pleasant, nut-like flavor. Its specific gravity is 0.919 to 0.923 at 15° C. At −3° C. (26.6° F.) it becomes thick, and at −5° C. (23° F.) it congeals. Concentrated sulphuric acid converts it to a brownish-red jelly. Its properties are purely nutritive and demulcent. *H. H. Rusby.*

BENTLEY SPRINGS.—Baltimore County, Maryland.

Post-Office.—Bentley Springs. Hotel, Glen House.

These springs are situated on the line of the Northern Central Railroad, a division of the Pennsylvania Railroad, about thirty miles from Baltimore and seventy miles from Washington. The elevation above tide water is about six hundred feet. In addition to the two principal springs there are perhaps as many as one hundred others, some of which have important chalybeate properties. The surroundings of the springs are very interesting and attractive. The following analyses of two of the chief springs are by Professor Aiken, formerly of the University of Maryland:

The "Nucta" or "Station" Spring.

One United States Gallon Contains:

Solids.	Grains.
Calcium carbonate	0.34
Sodium carbonate	.37
Magnesium carbonate	.27
Calcium sulphate	.30
Sodium chloride	.19
Silicic acid	.33
Iron (a trace) / Alumina and loss	.02
Total mineral contents	1.82
Organic matter	.36
Total solid contents	2.18

The Lower Spring.

Solids.	Grains.
Calcium carbonate	0.64
Magnesium carbonate	.68
Sodium carbonate	.46
Iron carbonate	.89
Sodium chloride	.27
Calcium sulphate	.35
Silicic acid	.43
Alumina and loss	.03
Inorganic contents	3.75
Organic matter	0.91
Total contents	4.66

The water is a mild example of the alkaline-saline-calcic class. It has been used for upward of thirty years, in kidney, liver, and stomach disorders, and in chronic bowel affections. It is used commercially. *James K. Crook.*

BENZACETINE. — Acet-amido-ethyl-salicylic acid — $C_6H_2,NHCH_2CO,OC_2H_5,COOH$. This occurs in colorless crystals which are almost insoluble in water and have a melting point of 205° C. (401° F.). Frank introduced it as a sedative and antineuralgic of special value in cases of migraine. The dose is gr. viij. to xv., which may be repeated in one hour if necessary. It may advantageously be combined with one or two grains of citrated caffeine. *W. A. Bastedo.*

BENZANILID.—(Phenyl benzamide.) This is one of the three anilids that have proved active medicinally. The others are salicylanilid and acetanilid. In benzanilid the salicylic acid or acetic acid of the others is replaced by benzoic acid. It occurs in small, white, shining scales, tasteless, odorless, insoluble in water, soluble in alcohol, 1 in 60. It is chemically and therapeutically allied to acetanilid. Kahn and Hepp, when investigating antifebrine, used it in a number of cases and found it to possess similar properties. The advantages claimed for it are that it possesses less toxic properties and after its use the rise of temperature is more slow, but notwithstanding these apparent advantages it has failed to become a popular remedy.

Its antipyretic action begins in from half an hour to one hour after it has been taken, and its maximum effect is reached in five or six hours. In ten or twelve hours its effect has quite passed away. It does not cause any disturbance of respiration or of digestion. The circulation is slowed, the vascular tension being reduced. In some cases large doses have altered the color of the urine, rendering it of a greenish tinge, which is increased after exposure to light. It is administered in doses of ten or fifteen grains; sixty to ninety grains, during the twenty-four hours, being well borne. *Beaumont Small.*

BENZENE.—Benzene, also called *benzol*, is the simplest hydrocarbon of the aromatic series, having the formula C_6H_6. It is thus a definite chemical compound, and must carefully be distinguished from *benzin*, a composite substance obtained as a distillate from coal oil (see *Benzin*). Benzene or benzol is a thin, colorless fluid, very volatile and very inflammable, and, when pure, of a not disagreeable aromatic odor. It is practically insoluble in water, but dissolves in four parts of alcohol. It may be obtained by distilling a mixture of benzoic acid and lime, or by fractional distillation of the material known as *coal naphtha*, a derivative of coal tar.

Benzene is of more value in pharmacy than in medicine. For pharmaceutical purposes it is notable for its extensive solvent power, dissolving readily such comparatively insoluble substances as india rubber, gutta-percha, sulphur, phosphorus, iodine, many resins and many alkaloids dissolving readily in it. Physiologically, benzene has little local effect, but taken internally determines intoxication, coma, and anæsthesia. It has been given internally in doses of a few drops in dyspepsia associated with fermentation of the ingesta, and also in trichinosis, but is rarely employed and is not official in the United States Pharmacopœia. *Edward Curtis.*

BENZIN.—Under the title of *Benzinum*, Benzin, the United States Pharmacopœia makes official the substance commonly known as *petroleum benzin* or *petroleum ether*. It is thus defined and described: "A purified distillate from American petroleum, consisting of hydrocarbons, chiefly of the marsh-gas series [C_5H_{12}.C_6H_{14}, and homologous compounds]. Benzin should be carefully kept in well-stoppered bottles or cans in a cool place, remote from lights or fire. A transparent, colorless, diffuse liquid, of a strong characteristic odor, slightly resembling that of petroleum, but much less disagreeable, and having a neutral reaction. Specific gravity: 0.670 to 0.675 at 15° C. (59° F.). Boiling point, 50° to 60° C. (122 to 140° F.). Insoluble in water; soluble in about six parts of alcohol, and readily soluble in ether, chloroform, benzol, and fixed and volatile oils. Benzin is highly inflammable, and its vapor, when mixed with air and ignited, explodes violently" (U. S. P.).

Much confusion arises from the similarity in name and general appearance between this substance—a mixture of hydrocarbons of the marsh-gas series—and the chemical body *benzene* or *benzol* (C_6H_6), a single hydrocarbon of the aromatic series (see *Benzene*). The two articles must carefully be distinguished.

Benzin is not used in medicine, but is useful to the pharmacist for its solvent powers over fats, resins, volatile oils, and other bodies *Edward Curtis.*

BENZOIC ACID AND BENZOATES.—*Benzoic Acid*, $HC_7H_5O_2$, formerly known as *flowers of benzoin*, is a monatomic acid of the aromatic series, existing ready formed in a number of balsams and gum resins, notably in benzoin, and also easily obtainable, artificially, by decomposition of hippuric acid or of derivates of toluene or of naphthalin. The benzoic acids of commerce are derived from all these sources. Benzoic acid from benzoin is characterized by a special degree of lightness and fluffiness, and by a distinct benzoin odor. The acid derived from hippuric acid is manufactured out of the urine of cows and horses, and formerly was distinguishable by a urinous odor, but as at present made is quite pure and entirely free from such smell. The acid from this source is commonly known, commercially, as *German benzoic acid*.

Benzoic acid is official in the United States Pharmacopœa under the title *Acidum Benzoicum*, Benzoic Acid. The source of the article is not prescribed, but the acid is said to be "usually obtained from benzoin by sublimation, or prepared artificially, chiefly from toluol." Although no mention is made of the German acid manufactured out of horse urine, yet it is proper to say that the article so derived, if free from smell, is perfectly pure and decent for medical use. A benzoic acid made from toluene, and having an odor like that of bitter almonds, is probably not pure, and such a sample should be rejected. Benzoic acid is described officially as follows: "White or yellowish-white, lustrous scales or friable needles, odorless, or having a slight, characteristic odor resembling that of benzoin, and of a warm, acid taste; somewhat volatile at a moderately warm temperature, and rendered darker by exposure to light. Soluble, when pure, in about 500 parts of water, and in 2 parts of alcohol at 15° C. (59° F.); in 15 parts of boiling water, and in 1 part of boiling alcohol. Also soluble in 3 parts of ether, 7 parts of chloroform, and readily soluble in carbon disulphide, benzol, fixed and volatile oils, but sparingly soluble in benzin. Benzoic acid volatilizes freely with the vapor of water. On heating it to 100° C. (212° F.), it begins to sublime. At 121.4° C. (250.5° F.) it melts, and at a higher temperature it is consumed without leaving a residue. The acid sublimed from benzoin has a lower melting point and a greater solubility in water. Benzoic acid has an acid reaction" (U. S. P.).

Benzoic acid "should be kept in dark amber-colored, well-stoppered bottles, in a cool place." As to effects upon the animal system, benzoic acid is locally irritant to sensitive surfaces, its concentrated vapor, if inhaled, causing violent sneezing and coughing, and even bronchial inflammation. Yet, when swallowed, benzoic acid is singularly innocent. Even gram doses cause but a feeling of abdominal warmth and increase of bronchial mucus, and serious derangement is scarcely possible by any likely dosage, intentional or accidental. The action of benzoic acid, of interest in medicine, is upon the urine. Under the influence of the drug, given by the mouth, an acid urine tends to be of increased acidity, an alkaline to become acid, and a urine prone to decompose before voidance to lose such tendency. The increased acidity of urine determined by benzoic acid is mainly accounted for by the presence in the secretion of hippuric acid, undoubtedly derived, by chemical change, from the benzoic acid itself. This conversion of benzoic into hippuric acid is probably wrought in the kidneys (Meissner and Shepard). Arrest of putrefaction in urines by benzoic acid is probably simply an example of the general antiseptic action of the drug. Opposite statements have been made by investigators concerning the influence of benzoic acid, taken medicinally, upon urinary excretion of urea and uric acid, some finding the proportion of one or other of these excreta to be lessened, and others observing the same to be unaffected.

Besides the action upon the urine, benzoic acid is important for its antiseptic power, in which it probably stands on a par with salicylic acid.

The therapeutic applications of benzoic acid are principally the internal giving of the acid under its own form

for the acidifying of the urine in cases in which that secretion tends to be alkaline and unduly phosphatic, or for the prevention of decomposition of the urine in the bladder in cases of vesical catarrh. The acid may also be used as an antiseptic. In saline combination, principally as sodium benzoate, benzoic acid has also been employed in acute rheumatism, as an innocent but therapeutically effective substitute for salicylic acid or the salts thereof (Senator), and in pulmonary consumption, diphtheria, scarlet fever, and other diseases of that category. In these applications, however, the reputation of the medicine is, at the present writing, decidedly on the wane.

For its legitimate use in urinary disorders, benzoic acid may be given several times daily in doses of from 0.65 to 2.00 gm. (gr. x. to xxx.), administered in pill form, with soap as the excipient, or given in mixture. Free solution of benzoic acid in water can be determined by the addition of four parts of sodium phosphate or one and a half parts of borax. Solutions for antiseptic purposes should range from two-per-cent. strength upward, solution in water being effected by the additions just cited.

BENZOATES.—Such of the benzoates as are used in medicine are employed for the sake of the benzoic acid of their composition. Their discussion, therefore, belongs to this place. The benzoates official in the United States Pharmacopœia are the *sodic*, *lithic*, and *ammonic* salts.

Sodium Benzoate, $NaC_7H_5O_2$.—This salt is official as *Sodii Benzoas*, Sodium Benzoate, and is described as "a white, amorphous powder, odorless, or having a faint odor of benzoin, and a sweetish, astringent taste. Permanent in the air. Soluble, at 15° C. (59° F.), in 1.8 parts of water and in 45 parts of alcohol; in 1.3 parts of boiling water, and in 20 parts of boiling alcohol. When heated, the salt melts, emits vapors having the odor of benzoic acid, then chars, and finally leaves a residue of sodium carbonate and carbon. To a non-luminous flame it imparts an intense yellow color. The aqueous solution is neutral to litmus paper" (U. S. P.). The salt should be kept in well-stoppered bottles. Sodium benzoate is made by treating a sodium carbonate, in hot saturated aqueous solution, with benzoic acid, and the quality of the salt will be determined by the quality of the benzoic acid used in its manufacture. The article described by the Pharmacopœia is intended to be made from benzoin-benzoic acid. Specimens made from hippuric-benzoic acid and from toluene-benzoic acid have been found to be less freely soluble in water than the above, and to yield pale yellow and turbid solutions of an acrid, bitter taste, and of an odor of horse sweat or of bitter almonds, according to the source of the benzoic acid.

Physiologically, sodium benzoate is about as harmless as a salt can be, but has been found to produce fully the curative action of benzoic acid itself in acute rheumatism, and has been loudly vaunted as of wonderful avail in pulmonary consumption, diphtheria, etc. It has been given internally in doses amounting to from 5 to 20 gm. (gr. lxxv. to ccc.) a day, without serious derangement, and for pronounced effect in acute rheumatism the fullest limit of such dosage may be necessary. In diphtheria, inhalations of atomized spray and insufflations of the powdered salt upon the diphtheritic patch have also been practised.

Lithium Benzoate, $LiC_7H_5O_2$.—The salt is official as *Lithii Benzoas*, Lithium Benzoate. It is thus described: "A light, white powder, or small, shining crystalline scales; odorless, or of faint benzoin-like odor, and of a cooling, sweetish taste; permanent in the air. Soluble, at 15° C. (59° F.), in 4 parts of water, and in 12 parts of alcohol; in 2.5 parts of boiling water, and in 10 parts of boiling alcohol. The presence of sodium benzoate increases the solubility in water and lessens that in alcohol" (U. S. P.). The salt reacts to heat the same as does sodium benzoate, except that it colors a flame crimson instead of yellow.

Lithium benzoate is made by direct decomposition of lithium carbonate by benzoic acid; and, as in the case of the making of sodium benzoate, benzoin-benzoic acid should be used for the manufacture.

Lithium benzoate is an innocent salt, seemingly yielding to a certain degree similar results to benzoic acid itself in urinary affections (see under Benzoic Acid, *ante*). It has been used in such conditions in the place of the uncombined acid, in doses of from 1 to 2 gm. (gr. xv. to xxx.) several times daily.

Ammonium Benzoate, $NH_4C_7H_5O_2$.—The salt is official as *Ammonii Benzoas*, Ammonium Benzoate. It is thus described: "Thin, white, four-sided, laminar crystals, odorless, or having a slight odor of benzoic acid, a saline, bitter, afterward slightly acrid taste, and gradually losing ammonia on exposure to the air. Soluble at 15° C. (59° F.), in 5 parts of water and in 28 parts of alcohol; in 1.2 parts of boiling water and 7.6 parts of boiling alcohol. When strongly heated, the salt melts, emits vapors having the odor of ammonia and benzoic acid, and is finally completely dissipated" (U. S. P.). The salt is made by adding benzoic acid to water of ammonia, and, as in the case of the other benzoate, benzoin-benzoic acid should be used in the making. This benzoate should be kept in well-stoppered bottles.

Ammonium benzoate is an innocent salt, and affects the urine after the manner of benzoic acid itself. It is used in place of the acid in urinary disorders (see Benzoic Acid, above), in doses of from 1 to 2 gm. (gr. xv. to xxx.) several times daily. It amounts, medicinally, to a soluble form of benzoic acid, and can readily be made extemporaneously in solution by saturating benzoic acid with water of ammonia. Let the amount of benzoic acid to be prescribed be mixed with a little water, then neutralized with water of ammonia, and the whole brought to a desired volume of solution by further addition of water (Squibb).

Edward Curtis.

BENZOIN.—BENZOINUM. "*Gum Benjamin.*" "A balsamic resin obtained from *Styrax Benzoin* Dryander (fam. *Styraceæ*)" (U. S. P.). The tree here named is known to be the source of the *Sumatra* variety of benzoin, but is probably not that of the *Siam* variety. It is a good-sized tree, rather widely distributed through the East India Islands, and to a considerable extent cultivated in Sumatra. At the age of about six years, when the tree is six to eight inches in diameter, collections begin. They are continued for from fifteen to twenty years, the product becoming darker and more inferior with each succeeding year. The sap exudes from incisions made for the purpose, as a milky juice which is collected in tears, at first whitish, then becoming yellow, or rusty brown, but still milky white when fractured. If this concrete product of the young trees is packed separately, it results in a more or less loosely constructed cake, of excellent quality. Ordinarily, however, there is a considerable quantity, often very large, of a darker substance which, run, or perhaps kneaded, into the interstices, and then hardening, converts the contents of the boxes in which it comes packed into a solid mass of a pinkish or reddish gray, or of a gray or sometimes gray-brown color, in which the white or yellowish tears are firmly embedded. It is believed that this interstitial substance consists of the soft product from old trees, or even of a very inferior substance obtained by barking and scraping the trunks. Even this inferior variety may be regarded as good in comparison with the very large quantity of adulterated benzoin which reaches us. Adulteration was formerly practised by embedding large stones in the centre or ends of the mass, but the inspection of the blocks by splitting them diagonally in various directions checked this, and recourse is now had to fine gravel, sand, or other earthy matter, for the purpose. Benzoin thus adulterated is called "drossy." Benzoin, when cold, breaks with a sharp, brittle fracture, and a shining or sparkling surface, but becomes more or less plastic or adhesive in a warm atmosphere. It has a very pleasant balsamic odor and a rather mildly aromatic, somewhat acrid and unpleasant

taste. Benzoic acid sublimes from it. Five parts of warm alcohol should dissolve nearly all of it, if pure.

Siam benzoin is packed in similar boxes, but consists of a porous mass of tears only, loosely cohering or separate. These tears are known in trade as "marbles" or "almonds" and the respective grades are known as "large" or "small marbled." The outer surface of these tears becomes of a darker yellow or brown than the Sumatra, but they also are white internally. They are much more fragrant, reminding one somewhat of vanilla. This variety is much more expensive than the Sumatra, and is little subject to adulteration.

Penang benzoin was a very highly valued variety of Sumatra, but is now obsolete in commerce.

The principal constituent of benzoin, as to percentage, constituting almost the whole of it, is resin, but its active constituent is benzoic acid, which see. There is a trace of cinnamic acid and a little volatile oil.

Action and Uses.—So far as the medicinal action and use of benzoin is concerned, it is identical with benzoic acid, in proportion to its percentage. Otherwise it is used in pharmacy for perfuming medicinal substances or for rendering them antiseptic, and very largely in the manufacture of perfumery. The official preparations are the *Adeps Benzoinatus*, or *benzoinated lard*, which contains 2 per cent. of it, the tincture, of 20-per-cent. strength, which is the distinctly medicinal preparation, the dose 2 to 4 c.c. (fl. ʒ ss. to i.), and the compound tincture or "Friar's Balsam," containing 12 per cent. of benzoin, 8 per cent. of storax, 4 per cent. of balsam tolu, and 2 per cent. of purified aloes, the dose being the same as of the last. *Henry H. Rusby.*

BENZO-IODO-HYDRIN.—Glyceryl-chlor-iodo-benzoate; chlor-iodo-benzoyl glycerin ester—$ClIC_3H_5C_6H_5Co_2$. It is a product of the interaction of benzoyl iodide and epichlorhydrin, and is a yellowish-brown fatty mass, insoluble in water and glycerin, and soluble in alcohol, ether, and petroleum oils. At the boiling point of water it is decomposed, iodine being liberated. It is claimed that this substance possesses the same value as potassium iodide without any tendency to produce iodism or to derange the digestion. Two grains of benzo-iodo-hydrin may be given with sixty grains of sugar, this dose being equivalent to fifteen grains of potassium iodide.

W. A. Bastedo.

BENZO-NAPHTHOL. BETA-NAPHTHOL BENZOATE—($C_{10}H_7O$, C_7H_5O.) Obtained by the reaction that takes place between beta-naphthol and benzoic acid. It is a whitish, crystalline powder, very slightly soluble in water, freely soluble in chloroform and alcohol.

It is recommended as a substitute for salol or betol, having the advantages that benzoic acid possesses over carbolic or salicylic acid. When introduced into the intestines it breaks up into beta-naphthol and benzoic acid. The former is not absorbed and remains in the intestines until excreted; the latter also exerts a local antiseptic action, but ultimately is absorbed and eliminated with the urine.

This is one of the newer intestinal antiseptics that have secured a favorable recognition. Its continued use has added to its repute, and it may now be looked upon as a remedy of decided value. It has proved of value in ordinary fermentative changes in the intestine, and in the diarrhœas of children and adults, both acute and chronic. Reports show it to be of particular use in chronic conditions in which there are follicular disease and ulceration. In an epidemic of acute dysentery in Cuba it proved of marked value, the death rate in those cases in which it was employed being only two per cent., while under other methods of treatment it was nine per cent.

The ordinary dose is given as from five to ten grains three or four times a day, but when a more decided action is desired a larger dose must be administered—forty grains a day to children and from sixty to ninety grains to adults. No ill effects have been reported from the employment of this remedy. *Beaumont Small.*

BENZO-PHENONEID.—Tetra-methyl-diapsido-benzo-phenoid. A non-irritating though powerful germicide, obtained by the decomposition of an aniline dye. It is similar to pyoktanin, is soluble in 100 parts of water, and is not caustic. Like yellow pyoktanin it has been used in corneal ulcers, pustular keratitis, and various ulcerative lesions of the skin and mucous membranes.

W. A. Bastedo.

BENZOYL-AMIDO-PHENYL-ACETIC ACID.—CHC_6H_5CO,NHC_6H_5COOH. Amido-phenyl-acetic acid is dissolved in a twenty-five-per-cent. solution of sodium hydroxide, warmed, and benzoyl chloride added; this mixture is then poured into dilute hydrochloric acid, and the resulting precipitate washed and dried. It is in white, needle-shaped crystals, slightly soluble in water, and forming with the alkalies soluble salts. Both the acid and its salts are used as antiseptics in the alimentary tract, and they promise to be of value when putrefaction is taking place in the small intestine, with headache, indicanuria, etc. Clinical data are wanting.

W. A. Bastedo.

BENZOYL-EUGENOL.—$C_6H_3,C_3H_5,OCH_3,OCOC_6H_5$—a combination of benzoic acid and eugenol, combining the antiseptic properties of oil of cloves with those of benzoic acid. It occurs in large colorless prisms or in small needle-shaped crystals, is odorless and tasteless, insoluble in water, and freely soluble in alcohol, ether, chloroform, and acetone. It is an intestinal antiseptic, and being to some extent eliminated by the lungs, it acts as a stimulant and antiseptic to the respiratory tract. So far its use has been confined to cases of pulmonary and intestinal tuberculosis. Dose, gr. vij. to xv. in powder or capsule, or mixed with milk.

W. A. Bastedo.

BENZOYL-TROPEINE.—$C_8H_{14}C_6H_5CONO$. Tropine, the mother substance of atropine, is heated to 100° C. with benzoic and dilute hydrochloric acids. The resulting silky needles constitute benzoyl-tropeine. They are insoluble in water, have a strongly basic reaction, and with acids form soluble salts. This compound seems to stand chemically between cocaine and atropine, and it partakes of the nature of each. Thus Filehne found it to be a valuable local anæsthetic when applied to the eye, it at the same time causing dilatation of the pupil. The soluble salts may be used in one to four per-cent. solution. *W. A. Bastedo.*

BERBERINE.—$2(C_{20}H_{17}NO_4 + 9H_2O)$. An alkaloid obtained chiefly from *Berberis vulgaris* L., but very common in other plants, especially in the families *Berberidaceæ*, *Ranunculaceæ*, and *Menispermaceæ*. It occurs in yellow, needle-shaped crystals, or as a yellow crystalline powder, and is soluble in alcohol and hot water. It forms numerous yellow crystalline salts. It is not poisonous. Aside from its effects as a simple bitter, its physiological action is rather weak. It is somewhat stimulant to unstriped muscular fibre, yet it causes a fall of blood pressure and slightly lowers the temperature. Large doses are irritant and may produce purgation. It is usually given as the sulphate. The dose as a tonic is 0.03 to 0.06 gm. (gr. ss. to i.). Doses of ten to fifteen times these amounts are antiperiodic. *H. H. R.*

BERBERIS L.—BARBERRY. A genus of the family *Berberidaceæ*, containing more than one hundred species, very widely distributed throughout the north temperate zone and extending along the mountains into and through the tropics. They are beautiful erect or prostrate, yellow-flowered shrubs or small trees, the evergreen leaves mostly pinnate and usually spinulose-toothed. All parts are permeated by the alkaloid *berberine*, the largest percentage occurring in the bark, and more particularly in that of the root. In most places where the species grow they have gained a high reputation as bitter tonics.

B. vulgaris L. is an erect species of Europe and ad-

jacent Asia, naturalized to some extent in North America, its scarlet fruit largely used in olden times as cranberries now are. Both the root and the bark have long been used medicinally as an antiperiodic, febrifuge, and tonic. Besides the berberine, it contains the alkaloids oxyacanthine and berbamine. Oxyacanthine is at first white, but turns yellow on exposure to light. The two last-named alkaloids apparently do not exert much influence, as the action of berberis is practically that of its berberine.

B. aquifolium Pursh. Oregon grape root or mountain grape, is a low, diffuse, blue-fruited species, very abundant in the Northwestern United States. It holds a remarkable place in the esteem of the miners and mountaineers, who rely chiefly upon this and the mountain sage (*Artemisia frigida*) in the treatment of fevers. Its constituents are about the same as those of *B. vulgaris*. The root is used. Very many reports agree in attributing to this drug, in addition to the ordinary tonic properties of a vegetable bitter, a special power in stimulating nutrition. The dose of both species is 0.2 to 0.6 gm. (gr. iij. to x.). Large doses are laxative. The best form of administration is the powder, fluid extract, or tincture.

In India, *B. aristata* D.C., *B. Lycium* Royle, and *B. Asiatica* Roxb. are similarly employed.

Henry H. Rusby.

BERCK-SUR-MER.—A sea-coast village in the Department of Pas-de-Calais, France, lying upon the shore of the English Channel. This place is mentioned only in order to call attention to the seaside hospital there existing, which has accommodations for five hundred patients. Lombard tells us, in his "Traité de climatologie médicale," vol. iv., p. 604, that this hospital was established in 1870, in consequence of the excellent results in the treatment of cases of scrofula and rickets obtained at the hospital, containing one hundred beds, that had been founded at this place by the city of Paris for the use of the poor. The present hospital contains eighty beds, intended for the children of such parents as can afford to pay the small sum of one franc eighty centimes (thirty-six cents) per diem for their board, lodging, and medical treatment. The idea of founding such establishments for the benefit of poor children, the victims of scrofula and kindred diseases, appears to have originated with the Italians; and no less than thirteen such charitable institutions exist upon the Mediterranean and Adriatic shores of the Italian peninsula. The reports of these hospitals show excellent results from this most admirable and commendable charity. At Biarritz, Cette, Cannes, Arcachon, Pen Bron, Cap Breton, Hyères-Giens, and Ver-sur-Mer, as well as at Berck-sur-Mer, the French have made further provision for this class of patients.

Huntington Richards.

[There are also hospitals or sanatoria for scrofulous children on the coasts of Holland, Belgium, Denmark, Austria, Germany, Russia, and England, the one at Margate having been founded in 1796.

It is well to emphasize here the great value of seaside residence for scrofulous or tuberculous children, and the importance of such establishments as these upon the coasts of the various European countries, where at the same time the children can receive proper attention and nourishing food. In this country the example of Europe might well be followed in this respect, and many of our admirable seaside resorts be utilized for this purpose.—*E. O. O.*]

BERGAMOT, OIL OF.—Oleum Bergamottæ. "A volatile oil obtained by expression from the rind of the fresh fruit of *Citrus Bergamia* Risso et Poiteau (fam. *Rutaceæ*)" (U. S. P.). The bergamot tree is a small evergreen, very much like the bitter orange in almost all respects, but the leaves are obovate, with narrowly winged petioles, and the flowers are smaller and fewer. It is not known in a wild state—indeed, it was not known at all until about two hundred years ago, when it appeared in the south of Europe. There is no doubt it is a hybrid or cross of some kind, probably between the bitter orange and the lemon or citron. The fruit is about as large as a small orange, and has the same general structure. It is rounded, pear-shaped, about as broad as long, with a broad, flat, or even depressed apex; the skin is soft, smooth, yellow, and very fragrant. The pulp is sour and bitter.

Bergamots are raised in the vicinity of Reggio, in the south of Italy, and in Sicily, and the oil is exported from Messina and Palermo. This is collected mechanically by rupturing the vesicles, sometimes by the old sponge process used with oranges and lemons in obtaining their oils, but more generally now by a sort of hand-mill, into which the fruits are put whole, and rolled and rubbed against a series of knives, which cut or scrape the surface and so liberate the oil. It flows to the bottom of the mill, and out through suitable apertures. One hundred fruits yield two and a half or three ounces of the oil (Flückiger).

It is a thin, mobile, pale-green, or greenish liquid, with a very fragrant, pleasant odor, and a bitter, aromatic taste. Its specific gravity is 0.883 to 0.886, its reaction slightly acid. Its active portion is linaloyl acetate. Like the essential oils in general, it dissolves readily in alcohol, chloroform, ether, and fats, and only very sparingly in water. The green color is due to chlorophyll.

The medical properties of oil of bergamot are those of essential oils in general, but it is never used internally. On the other hand, its delicious odor has made it a universal favorite in perfumes and toilet preparations. The world-renowned Cologne water has it as its principal ingredient, modified by other aurantiaceous oils. There are numerous formulæ for making it; one, formerly official as *Spiritus Odoratus*, is as follows:

Oil of Bergamot	16 parts.
Oil of Lemon	8 "
Oil of Rosemary	8 "
Oil of Lavender Flowers	4 "
Oil of Orange Flowers	4 "
Acetic Ether	2 "
Water	158 "
Alcohol	800 "
	1,000 parts.

W. P. Bolles.

BERIBERI. See *Neuritis.*

BERKELEY SPRINGS.—Morgan County, West Virginia.

Post-Office.—Berkeley Springs. Hotel.

Access.—Viâ Baltimore and Ohio Railroad to Hancock Station; thence by Berkeley Springs and Potomac Railroad direct to springs. Trains on the latter road make close connection with all day trains during the season. The location is six miles southwest of Potomac River and Hancock Station.

These historic old springs are situated in a narrow valley, about eight hundred feet above the sea level, and issue from the base of a steep ridge rising at this point about four hundred and fifty feet above the valley. Tradition has it that the waters here were well known to the aborigines, who, although generally at war among themselves, established a standing truce around the springs, that all might avail themselves of their potent virtues. They have been known and used by the whites since 1730, and it is said they were visited by George Washington while employed with a surveying expedition in 1748. The Father of his country was so appreciative of the many attractions of the neighborhood that he afterward acquired property immediately adjacent to the principal spring, on which he erected two "comfortable and convenient houses." General Horatio Gates, Charles Carroll of Carrollton, and other well-known figures of Revolutionary days were also represented among the owners in the old town established in 1776.

The location of Berkeley is in a beautiful mountain region, covered for the most part by primeval forests, with a botanical undergrowth peculiarly rich, varied, and interesting. The scenery is wild and romantic, and the country is threaded with pleasant walks and drives in all directions. The air is pure and wholesome, and the heat during the summer months is rarely oppressive. The streams in the neighborhood are well stocked with fine game-fish, chief among them being the black bass. The forests also abound in the larger game, including deer, wild turkeys, and pheasants, which afford good sport after September 1st. The spacious hotel at Berkeley, having a capacity for five hundred guests, has recently changed hands, and has been entirely renovated and refitted. Water from the spring is supplied to each floor. All varieties of hot, warm, and cold baths are at hand, and two large plunge and swimming pools have been constructed. The springs discharge from five principal sources, all within a radius of one hundred yards. The water is clear and sparkling, and tasteless. Its temperature is 75° F., which does not vary, and the flow is about one hundred and twenty thousand gallons per hour. The following analysis was made by Prof. A. A. Hayes, of Massachusetts, in 1855:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Calcium carbonate	5.00
Calcium crenate	3.64
Iron crenate	.08
Sodium chloride	.89
Calcium silicate	.64
Magnesium sulphate	.36
Calcium chloride	.21
Loss	.06
Total	10.88

The gaseous contents are one-twenty-eighth of the volume of the water, and are composed as follows in one hundred parts:

Carbonic acid	19.00
Oxygen	16.60
Nitrogen	64.30
Total	99.90

The water is evidently of the light saline-calcic variety. An analysis made by J. H. Dickson, chemist of Pittsburg, Pa., in 1892, shows a total of 13.49 grains per United States gallon. The qualitative results are practically identical with those above shown. The baths at Berkeley have been celebrated for many years in the treatment of gout, sciatica, and rheumatism. The internal use of the water is said to produce excellent results in chronic dyspepsia and diarrhœa. Many Virginia families take their children to this resort on account of its reputation as a restorer in rachitis and general feebleness and on account of its value in summer complaints during the period of dentition. The baths possess a marked cosmetic effect, rendering the skin soft, fresh, and elastic, and aiding in the removal of tans and freckles. There are also in close proximity two strong chalybeate springs and a sulphur spring. *James K. Crook.*

BERKSHIRE HILLS.—The hilly country lying between the nearly parallel ranges of the Hoosac and Taconic Mountains, in the extreme western part of the State of Massachusetts, has long been noted for the beauty of its scenery and for the general healthfulness of its climate, and has become, in consequence, a very favorite and fashionable resort, more particularly for dwellers in the cities of Boston and New York who desire to escape from the heat and vitiated air of a large town during the summer months. Not only do many such persons possess, in and about the chief towns of this region, handsome and attractive homes, where they reside during the warmer months of the year, but a considerable number of the wealthier class reside in this neighborhood throughout the entire course of the year.

The Hoosac range of hills vary in height between 1,200 and 1,600 feet, while Greylock, the highest peak of the Taconics, rises some 3,500 feet above the sea level. The summer climate of the Berkshire country is cool, and it is claimed that at all seasons a protection is here enjoyed against the dampness brought by easterly winds from the Atlantic and by westerly winds from the Great Lakes, a good part of their load of moisture being deposited by these winds upon the Hoosac Mountains, which form the eastern, and upon the Taconic Mountains, which form the western, boundary wall of the region.

The length of the Berkshire Hill country is about fifty miles from north to south; its breadth from east to west about fifteen or twenty miles. The following remarks on the healthfulness of the country are quoted from a paper written by Dr. J. F. A. Adams, of Pittsfield, and read before the Berkshire District Medical Society, December 27, 1883: "The registration reports show that the mortality from consumption is less in Berkshire than in any other county of the State, being but little more than half what it is in some of the maritime counties, and physicians know that of the cases which do occur here, the great majority are factory operatives, whose mode of life renders them peculiarly liable to this disease. . . . The dry atmosphere tends also to the prevention of rheumatism, which is very prevalent along the seaboard. For children the air is extremely favorable, cholera infantum, the summer scourge of cities, being rarely seen, and other summer diseases are comparatively mild. . . . Although malaria was for many years quite unknown in Berkshire, it has, since 1877, existed in a few low places adjacent to reservoirs or swamps. It is now, however, fast disappearing, and the indications are that it will soon become extinct. Those localities which under any circumstances would naturally be selected for a healthful residence have not been invaded, excepting here and there in the immediate vicinity of some marshy spot, and we need not regard this temporary and localized prevalence as an objection to taking up a residence in Berkshire. No part of the world possesses a more enchanting summer and autumn than Berkshire."

The winters in the Berkshire Hill region are decidedly cold, as the figures given below will show; but they are spoken of by the writer just quoted as being "delightful, with a dry, crisp, stimulating atmosphere, and plenty of snow." The universal testimony borne by residents and by visitors as to the purity and the bracing effect of its atmosphere would seem to recommend this region as a place of summer sojourn not only for persons suffering from incipient phthisis, but also for those whose general health has suffered impairment by overwork and by prolonged residence in the vitiated air, and amid the social and business excitement, of a great city; while for some persons who are merely "threatened with," or who, perhaps, may have already manifested in slight degree the commencing lesions of pulmonary phthisis, and who cannot go to such places as Davos, Colorado, etc., a continued residence among the Berkshire Hills, winter and summer, would be likely to check, and, perhaps, to arrest permanently, the progress of the disease. For such persons it would be a matter of no small importance that, over and above its beautiful scenery and its pure air and generally healthful climate, this particular region is superior to most similar sections of the United States, in that it presents throughout the year the attraction of good social advantages, a good percentage of its resident population being persons of cultivation and refinement.

The short tables herewith subjoined are extracted from those published in "Smithsonian Contributions to Knowledge," Nos. 277 and 222. Table A gives the latitude, longitude, height above sea level, and average monthly, seasonal, and yearly temperature of five of the chief towns or villages of the Berkshire country; Table B shows the extreme range of temperature throughout a series of years at one of these places (Williamstown); Table C presents the figures for the average rainfall, in inches, at the same place. *Huntington Richards.*

TABLE A.

Town.	Latitude.	Longitude.	Elevation.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Year.	Period of Observations. Begins.	Ends.	Extent. y's	m's.
Hinsdale..	42° 27′	73° 08′	1,360	24.13	21.15	23.87	42.08	53.65	64.76	69.59	66.27	58.54	43.08	33.00	23.17	39.87	66.87	44.87	22.82	43.61	July, '68	Dec.'70	2	3
Lenox	42 20	73 18	1,000	22.77	16.77	29.92	37.24	51.51	63.27	64.92	64.36	54.62	42.86	32.79	21.93	39.56	64.18	43.42	20.49	41.91	Jan., '37	Dec.'38	2	
Pittsfield..	42 27	73 15	1,084	....	23.30	28.20	34.41	....	64.42	67.28	64.32	57.33	49.11	31.10	26.17	....	65.34	45.85	....	....	1851	1853	1	3
Richmond.	42 23	73 22	1,100	21.80	24.17	30.83	44.01	57.83	68.18	71.57	68.70	62.22	49.55	36.03	25.60	44.22	69.48	49.27	23.86	46.71	1851	Dec.'70	14	10
Williamstown ..	42 43	73 13	686	21.63	22.92	30.93	43.60	55.78	65.56	69.66	66.52	58.81	46.92	30.34	25.28	43.44	67.25	47.36	23.28	45.33	Jan., '59	Dec.'70	36	8

TABLE B.

Town.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		Period of Observations.
Williamstown	61	61	71	87	95	95	97	96	95	85	72	59	Year of extreme heat, 1820 *	January, 1816. December, 1870.
	−30	−26	−12	17	28	35	43	39	25	13	−3	−19	Year of extreme cold, 1835...	

* Also in 1825 and 1828.

TABLE C.

Town.	Lat.	Long.	Elev'n.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Spring.	Summer.	Autumn.	Winter.	Year.	Period of Observations. Begins.	Ends.
Williamstown....	42° 43′	73° 13′	686	2.47	1.89	2.48	3.09	3.94	2.94	4.79	5.02	3.58	3.60	3.38	3.40	9.51	12.75	10.56	7.76	40.58	Sept., 1854.	Dec., 1867.

[The admirable results obtained at the Massachusetts State Sanatorium for Consumptives at Rutland, in the centre of the state, where the climatic conditions and elevation are similar to those of the Berkshire Hills, would indicate that the climate of the latter region is a favorable one for the hygienic-dietetic treatment of phthisis during the whole year. We now know from abundant experience that *cold* is no disadvantage, but rather an advantage, in the open-air treatment of phthisis when there coexist pure air, freedom from high winds, abundant sunshine, and a fairly dry atmosphere. The mortality from phthisis among the inhabitants of the Berkshires is more than fifty per cent. below the average for the State.—*E. O. O.*]

BERMUDAS.*—The Bermuda Islands lie about six hundred miles east of the North American coast, upon a coral reef which rises from the bed of the Atlantic Ocean. The entire group comprises no less than three hundred and sixty-five islands, but, with the exception of some twelve or fifteen, they are far too small to be suitable for human habitation, and of these twelve or fifteen inhabited islands, only five or six are of any considerable size. The largest island of the group is that of Great Bermuda, also called Long Island, which has a length of about sixteen miles, is but one mile and a half broad, and has an area of nine and a quarter square miles. When it is taken into account that the whole group of the Bermudas are comprised between Lat. 32° 14′ and Lat. 32° 25′ N., and between 64° 38′ and 64° 52′ W. Long., occupying, therefore, a portion of the earth's surface only 11′ long by 14′ wide, it is easy to understand how closely packed and crowded together these three hundred and sixty-five islands and islets must be. The coral reef underlying this little archipelago, and of which its cluster of islands are merely the most prominent portions jutting out above the surface the ocean, extends on the western side for a distance of about ten miles beyond the limits of the islands themselves, and it may well be understood that the navigation of these coasts, and the approach to the Bermudas, are extremely dangerous to ships, and that the services of skilled pilots are always required by vessels entering or leaving their harbors. Nevertheless, the art of scientific engineering has so far overcome these natural obstacles that the island is now one of the chief naval stations in the British empire, to which the Bermuda Islands belong. At Ireland Island, at the entrance of Hamilton harbor, is the largest floating dock in the world, and Hamilton harbor itself, although by no means so large as that of St. George's, is nevertheless navigable to vessels of many tons' burden, and is the port of entry for the steamers of the Quebec Steamship Company, plying between Bermuda and New York. At Grassy Bay, opposite Ireland Island, is the fleet anchorage of the British North Atlantic fleet, which makes its winter headquarters here.

* Considerable portions of the present text have, with the author's permission, been taken bodily from the excellent article contributed by Dr. Huntington Richards to the first edition of this HANDBOOK.—E. O. O.

The porous limestone rock, underlying the thin layer of surface soil which covers the islands, rapidly absorbs all the water which falls upon them from the clouds, so that no marshes are to be found anywhere throughout the extent of the Bermudas. Streams of running water and wells are equally absent, and rain water alone constitutes the supply for drinking and for washing purposes. This water is stored in large tanks, each house having one, and no new house is allowed to be occupied until the sanitary inspector is satisfied that the tank has been constructed as directed by law.

The character of the soil is especially suited to the construction of good roadways, hard and smooth, and delightful drives abound in every direction; cycling is also a favorite amusement, and the roads are excellent for this form of outdoor exercise. The facilities for fishing and yachting are also unsurpassed. The existence of the important naval station at Ireland Island insures to the Bermudas at all seasons a resident population possessing a larger degree of cultivation than is generally to be found in places having so small a number of inhabitants and situated so far from the greater centres of civilization. Such being the character of Bermuda society, it is no surprise to learn, as we do from the writer in Appleton's "Handbook of Winter Resorts," that at the town of Hamilton "there are good schools."

The following table, condensed from an article in the *British Medical Journal*, 1897, ii., p. 1233, upon "Bermuda as a Health Resort" by E. Harvey, M.D., gives the meteorological data:

CLIMATE OF BERMUDA—LATITUDE, 32° 17′ N.; LONGITUDE, 64° 47′ W. PERIOD OF OBSERVATION, JANUARY 1, 1893, TO DECEMBER 31, 1896. ELEVATION OF PLACE OF OBSERVATION, 150 FEET. (*Fahrenheit Scale.*)

	Average mean temperature deducted from three daily observations.	Average maximum temperature per period.	Average minimum temperature per period.	Mean monthly range of temperature per period.	Mean relative humidity. Per cent.	Average number of fair days.	Average number of clear days.	Average number of fair and clear days.	Average rainfall. Inches.	Prevailing direction of the wind.	Average velocity of wind in miles per hour.
January	62.5°	67.0°	57.5°	9.5°	76	18	2	20	6.25	N.W.	10.8
February	62.2	66.4	56.9	9.5	78	19	3	22	3.98	N.W.	1.8
March	63.9	67.8	56.8	10.0	80	21	3	24	6.53	N.W.	10.2
April	66.1	69.4	59.2	10.2	79	24	2	26	3.08	S.W.	7.9
May	71.4	76.0	64.0	12.0	82	21	2	23	4.86	S.W.	7.2
June	77.7	80.9	70.0	10.9	82	22	3	25	5.50	S.	6.9
July	79.8	84.5	73.1	10.4	83	25	2	27	5.10	S. and S.W.	6.8
August	81.0	85.6	74.0	11.6	81	22	3	25	4.23	S. and S.W.	5.0
September	78.0	83.2	72.3	10.9	80	23	3	26	7.11	S.	5.9
October	73.7	77.5	69.3	8.2	80	23	2	25	6.07	N.E.	8.7
November	68.6	73.5	65.3	8.2	81	19	1	20	3.89	N.E.	9.1
December	64.8	69.0	60.8	8.2	81	18	1	19	5.84	N.	11.0
Spring	67.1	....	....	....	80	66	7	73	14.47	N. and S.W.	8.4
Summer	79.5	....	....	....	82	69	8	77	14.92	S. and S.W.	6.2
Autumn	73.4	....	....	....	80	65	6	71	17.07	S. and N.E.	7.9
Winter	63.2	....	....	....	78	55	6	61	16.08	N.W. and N.	7.2
Year	70.8	....	....	....	80	255	27	282	62.54	S. and S.W.	8.4

From the above table it will be seen that the mean temperature for the year is 70.8° F.; for the winter 63.2°, and for the spring 67.1° F. The four months of December, January, February, and March have a mean monthly temperature not varying more than one or two degrees for the several months. The average mean yearly range of temperature is 10° F. The relative humidity is high, the annual mean being 80 per cent. The average rainfall for the year is 62.54 inches. The prevailing winds are from the south and southwest, and, from the personal experience of the writer, are frequent and high.

The average number of fair days in the year is 255, being about the same for each month. The average number of fair and clear days is 282,—considerably over two-thirds. The winter and early spring are the seasons of resort to the islands; the summer being extremely debilitating. The characteristics of the climate, then, are equability, a high degree of moisture, a pure atmosphere free from malaria and fogs, and a large number of fair and clear days.

Although, with the exception of the very damp and warm period, comprised chiefly within the two months of August and September, the degree of elevation attained by the thermometer in Bermuda may indicate a moderate summer temperature, and although the combined features of its climate may indeed render the place an agreeable residence for many persons during the warmer portion of the year, nevertheless, in view of its great humidity, the summer climate can hardly be considered desirable for, and is little likely to be sought by, invalids dwelling in the United States. To many such persons, on the other hand, its mildness and its comparative equability may well recommend the climate of these islands for residence during the whole or during a portion of the winter and spring seasons. There is little doubt that to all persons coming to Bermuda from the severely cold and very changeable winter weather of the Northern United States, the weather of the "Isles of Summer" would appear by comparison delightfully warm and very free from sudden changes of temperature; nevertheless, lest too great and too absolute a standard of equability should be expected by such would-be refugees from our own inclement winter weather, it may be well to remind them that the Bermudas are extra- and not intra-tropical islands.

Bermuda is connected by cable with Halifax, Nova Scotia, from which it is some seven hundred miles distant. The time of passage from New York, which is also about seven hundred miles distant from the island, is from forty-eight to sixty hours, and generally, on account of crossing the Gulf Stream, the voyage is rough and disagreeable. The population of Bermuda, in 1896, was 16,000. The vegetation is of a semi-tropical character, and very luxuriant. In the season one sees everywhere the white lily fields perfuming the air with their fragrance. The oleander bush grows also in great profusion, and is used for hedges; the banana, guava, pomegranate, avocado pear, tamarind, arrowroot, and many other semi-tropical fruits are found here. The onion, potato, and lily bulb are the principal products exported. In the private gardens many tropical fruits are also found. The houses are all built from the coral rock, and are likely to be damp. The accommodations are good, especially at Hamilton, the principal town of the island and the place generally selected by the visitor for his residence. Here there are several large hotels and some boarding-houses. Thanks to the presence, during the winter months, of the British North Atlantic fleet in the harbor, and of the garrison on shore, there is no lack of social attractions. The beautiful coral sea gardens, where one sees this curious product in an infinite variety of shapes and colors; the innumerable excursions by sea and by land; the dingey boat sailing; the golf, the bathing, and the fishing; the bicycling and the yachting —all these things afford an abundance of entertainment and outdoor exercise. There is no rainy season, and hardly ever an entirely wet day. The rain quickly soaks through the porous coral soil. The inhabitants spend the greater part of their life in the open air.

In conclusion I would say that Bermuda is not the sort of place to which patients suffering from phthisis should be sent. Nor is to be selected for cases of chlorosis, general anæmia, functional debility, angina pectoris, or palpitation associated with chlorosis. "The class of invalids most benefited by this climate are those in want of mental or bodily rest, or those who should spend most of their time in the open air; cases of mental disease with excitement; the neuralgic, hysterical, hypochondriacal; those addicted to the opium habit, and those who are sufferers from insomnia or from chronic disease of brain or cord" (Harvey: *loc. cit.*). To the overworked professional or business man of our Northern cities, Bermuda is a veritable paradise.

Edward O. Otis.

BETEL LEAF. See *Piper.*

BETEL NUT. See *Areca.*

BETHLEHEM, N. H., is picturesquely situated on the western slope of the White Mountains, in the northern part of the State. It is seventeen miles west of Mount Washington. It has been named the hub of the White Mountains, as almost all places of interest in this region are in close proximity to it. As it is located upon the west of the mountain range the air is very much dryer

than that to be found on the eastern side; for the humidity from the Atlantic Ocean is deposited on the eastern slope, while the filtered air is what we find in Bethlehem. Then, again, there is a scarcity of lakes and waterways of any extent in the vicinity, and for this additional reason, therefore, the climate contains less moisture than that found in regions where these abound. The normal population of Bethlehem is about 1,500 people, but as the place is a favorite summer resort, the number of inhabitants is increased by from 3,000 to 4,000 visitors during those months. There are ample accommodations for all classes of guests, from the modest New England farmhouse to the well-organized hotel.

Bethlehem is 1,459 feet above the sea level. The prevailing wind is southwest, and there are an unusually large number of clear days, the average for both July and August being 23; and out of 21 days in September, 17 were clear. Even during the days that are called cloudy, one can sit out-of-doors most of the time. The mean temperature for the season of July, August, and September is 62.3° F. The relative humidity, taken from the tables of Dr. W. H. Geddings, is 61 per cent. for the season.

mended as a substitute for salol in rheumatic affections, cystitis, intestinal catarrh, etc. It has the advantage over salol of being composed of less toxic constituents. The dose is from five to eight grains. In combination with salicylate of bismuth it is particularly recommended in the treatment of the summer diarrhœa of children and in typhoid fever. *Beaumont Small.*

BETONY WOOD.—*Stachys Betonica* Benth. (fam. *Labiatæ*) is a perennial herb, 30 to 60 cm. (one or two feet) high, with purple-red flowers, and long-stemmed, mostly radical leaves. These are from 5 to 8 cm. (two to three inches) in length, oblong crenate, heart-shaped at the base, and hairy. The plant is a native of Europe, growing in pastures and woods. The leaves, when fresh, have a faint, disagreeable odor—which mostly disappears upon drying—and a bitter astringent and nauseous taste.

Betony in former times had a high reputation for a variety of troubles; at present it is not in use. Dose of the dried leaves as a "nervine, expectorant, sudorific," etc., is from 1 to 3 gm. (gr. xv. to xlv.). The root is said to be emetic. *W. P. Bolles.*

CLIMATE OF BETHLEHEM, N. H.—LATITUDE, 44° 16′; LONGITUDE, 71° 41′. PERIOD OF OBSERVATION, JULY, AUGUST, AND FIRST THREE WEEKS OF SEPTEMBER, 1892, 1893, 1894, 1895, 1896, 1897, AND 1899; ALTITUDE, 1,459 FEET. OBSERVATIONS TAKEN BY C. F. McGAHAN, M.D. (*Fahrenheit Scale.*)

Month.	Mean temperature from 7 A.M., 2 and 9 P.M. observations.	Mean daily variation in temperature.	Mean temperature from maximum and minimum.	Mean maximum temperature.	Mean minimum temperature.	Absolute maximum temperature.		Absolute minimum temperature.		Relative humidity.* Per cent.	Wind.	Average number of clear days.	Average number of rainy days.	Average number of cloudy days.
						Highest.	Lowest.	Highest.	Lowest.					
July	65.0°	10°	67.7°	79.3°	36.2°	88°	68°	62°	50°	63	S.W.	23	5	3
August	62.5	11	62.9	75.3	50.5	86	69	59	39	60	S.W.	23	4	4
September	59.3	14	61.8	75.4	48.3	83	64	61	38	60	S.W.	17	3	1
Mean	62.3	....	64.1											

* Relative humidity is taken from the observations of the late Dr. W. H. Geddings.

It is here that the Hay Fever Association of the United States holds its annual meeting, and its members state that more of them are exempted from this disease at Bethlehem than at any other place. Even those who do not entirely escape the coryza in Bethlehem are exempt from the asthma; but most of the hay-fever sufferers pass through the summer here without realizing that they had ever been victims of the disease.

For the amusement of the visitors there are two golf links of nine holes each—one at Bethlehem and one at Maplewood Hotel, only a mile from the centre of the village. There is also a fine casino where provision is made for all indoor amusements.

The water supply is derived from a system of mountain springs which are located upon the mountain above the habitations. The water has been analyzed and found to be absolutely pure. The system of sewerage is thoroughly modern.

Charles F. McGahan.

BETOL.—The beta-naphthol ether of salicylic acid, analogous to salol, which is the phenyl ether of salicylic acid. It is obtained by the reaction between beta-naphthol and salicylic acid in the presence of a dehydrating agent. It forms in small, white, brilliant crystals, almost devoid of taste and odor. It is insoluble in water, but dissolves in alcohol and oils. Betol possesses antiseptic and antipyretic properties. It is not acted on in the stomach, but when it reaches the alkaline fluids of the intestines it breaks up into beta-naphthol and salicylic acid. It is recom-

BEX.—A popular thermal and climatic station in the Canton of Vaud, Switzerland. Famous "*salines.*"

LOCATION.—Bex is beautifully situated in an expansion of the Rhône valley, and is at no great distance from Vevey, on the lake of Geneva. It is 1,427 feet above sea level. The little village is well known in Europe, but only very slightly in America. The writer, having spent several seasons at this resort, knows that it deserves greater recognition than has been hitherto accorded to it in our country. The "salines" themselves are of no

FIG. 479.—View of Bex, Looking toward the Dent du Midi.

mean importance, and the principal bathing establishment is a modern and commodious one. As for milk, whey, and grape cures, there are few places where these

can be more advantageously taken than at Bex. Invalids have also rare opportunities there for beautiful walks through a charming country, and, for the more hardy, distant mountain excursions offer strengthening recreation.

ACCESS.—Bex is a station on the railroad running through the valley of the Rhône. The village and Grand Hotel des Salines are reached by carriage or stage in fifteen minutes. From Paris the route is viâ Geneva.

FIG. 480.—The Valley of the Rhône, Near Bex.

ANALYSIS.—The brine is conducted to the bathing establishment from the distant salt mines. Ten litres of the brine contain (Bischoff) 1,703 gm. of solids.

The principal ingredients, in ten thousand parts, are:

	Parts.
Chloride of sodium	1,567.0
Chloride of potassium	28.5
Chloride of magnesium	10.8
Sulphate of lime	67.6

Ten to twenty quarts of this brine are used for a bath.

The diluted brine is also employed internally, after having been charged with carbonic acid gas. It contains, in addition to the salts mentioned above, a small proportion of iodides and bromides.

INDICATIONS.—Apart from its advantages as a climatic resort, specially emphasized by the late Professor Lebert, Bex is now recognized to be an important bathing station. The climate is about that of Montreux, although, in spite of its mountain-protected position, harsh blasts occasionally sweep through the valley. The annual mean of the temperature is about 50° F.

The following class of cases do well at Bex: The so-called scrofulous affections, rheumatism in its subacute forms, catarrhal affections of the air passages, paretic and paralytic states after diphtheria and other infectious diseases, asthma, neurasthenia of the milder type, and the earlier stages of phthisis. Certain uterine affections, such as metritis, subinvolution, etc., are also benefited by a mild course of the baths. All patients in whom even moderate stimulation of the nervous system is liable to do harm should be warned against using the Bex treatment. The thermal establishment is thoroughly equipped with inhalation cabinets, sprays, douches, and the usual outfit for hydrotherapy. The quality of the grapes used for the cure is excellent.

ACCOMMODATION.—The *Grand Hotel des Salines* is an excellent establishment of its kind, situated at some distance from and about one hundred and fifty feet above the village proper. In the latter very reasonable and fairly good board is obtainable. The *Pension du Crochet* is a popular family hotel on a small scale. *Edmund C. Wendt.*

BIARRITZ.—A sea-coast town in the extreme southwestern portion of France, in the Department of the Basses Pyrenees, lying upon the shore of the Bay of Biscay, some five miles distant from Bayonne (Lat. 43° 27′ N., Long. 1° 37′ W.). At the present day Biarritz is well known as a fashionable seaside resort, possessing an excellent beach with a good surf, and having abundant and comfortable hotel accommodations and agreeable climate. It is much resorted to by visitors from all parts of France and from other countries during the bathing season, which not only comprises the summer months, but also extends much later into the autumn than is the case with similar seaside stations lying farther to the north. Although, as we are told by Dr. Bennet ("Winter and Spring on the Shores of the Mediterranean," fifth edition, 1875, p. 606), the town of Biarritz "has long been resorted to by the inhabitants of Bayonne and of the Pyrenean district, in summer, for its excellent sea-bathing," yet, as this author goes on to say, "it was all but unknown to fame until the Empress Eugénie brought it into notice by making it her marine autumnal residence." As an evidence of its present popularity we read in the "Encyclopædia Britannica" that "the permanent population of Biarritz, according to the census of 1871, was 3,164"; while, on the other hand, "the autumn visitors are estimated at from 12,000 to 15,000." The coast at Biarritz is decidedly rocky and very picturesque, being in this respect as different as possible from the low-lying and purely sandy shores of the Department of the Landes, which border the Bay of Biscay farther to the north. To the vast extent of sand-covered country constituting the greater portion of this Department (Landes), and comprising in all an area of some 3,700 square miles (Bennet, *op. cit.*), the climate of Biarritz is doubtless indebted for at least a part of that dryness and of that mildness in winter for which it is celebrated. The summer heat at Biarritz is tempered by the prevailing westerly winds, which blow from the Atlantic. The situation of the town, directly upon the shore of the ocean, is also another element in insuring to it a mild and a comparatively equable temperature during the winter months. Its climate at this season is very similar to that of Arcachon, which has already been described in preceding pages of this Handbook (see *Arcachon*).

The reputation of Biarritz as a winter resort is of still more recent date than is its great popularity as a summer bathing station, and doubtless depends in a measure upon the latter. As explained by Dr. Bennet, the very extensive preparations for the entertainment of summer and autumn guests have a tendency to cheapen considerably the cost of living in Biarritz during the colder months which follow; and this cheapness of living is offered by the doctor as an inducement, and in many cases a most important inducement, to attract thither a class of invalids requiring a place of residence for the winter season, which offers the advantage of a mild and equable climate unaccompanied by the high, and too often exorbitant, cost of living which frequently prevails at such sanitaria. "It is impossible," says this author, "that a town situated on the boisterous Bay of Biscay can be equal in point of climate to the Riviera undercliff, or to the east coast of Spain, in cases of severe disease in which the best climate that can be found is required. But still there must be many cases in which the sunshine and mild temperature of the southwestern coast of France may be sufficient. Moreover, the question of expense is often, unfortunately, a paramount consideration." Another class of persons to whom Dr. Bennet proposes a sojourn at Biarritz (and in this instance a sojourn not during the winter, but during the bathing season) are such residents in the British Isles as have for various reasons been unable to resort to the seaside stations of their own country during the months of July and August. "Those who cannot resort to our

own coasts in July and August, and to whom a mild or warm temperature is essential, have thus the opportunity of still enjoying at Biarritz summer sea-bathing at a time when with us both the sea water and the external atmosphere are becoming chilly." (The time referred to by the doctor in the above-quoted passage is the autumn season, the two months of September and October, of which he had just been speaking.)

Full and detailed statistics for the climate of Biarritz the writer is unable to present. The following statements, both general and particular, respecting the climatic features of the place have been culled from the pages of various authors, and are herewith presented to the reader.

The mean winter temperature at Biarritz is given by Weber (Ziemssen's "Handbuch der Allgemeinen Therapie") as 6° to 8° C. (= 42.8° to 46.4° F.). The "Dictionnaire usuel des sciences médicales" gives the figures of the three months of January, February, and March for a single year (1868) as follows: January, 40.26° F.; February, 40.91° F.; March, 44.62° F. The mean of these would be, of course, 41.93° F., a decidedly lower figure than that just given on Weber's authority, and indicating for the winter of 1868 a temperature probably below the normal, especially if we take into account that this figure (41.93° F.) is the mean for January, February, and March, and not for the three months of winter, viz., January, February, and December. The average spring temperature is placed by Weber at from 11° to 12° C. (= 51.8° to 53.6° F.); that of the summer season at about 64.4° F. Dr. Bennet refers to observations of the temperature made at Biarritz by the Rev. Mr. Crow during the winter of 1862. The average of this gentleman's observations "made at 8 A.M. on a north wall" during January of that year was about 45° F.; the highest temperature being 62° F., the lowest 30° F. "In February there was some very cold weather. During seven days the highest temperature was 34° F. (at 8 A.M.), the lowest 24° F. With the exception of that week, the weather was glorious, the thermometer after January varying from 48° to 62° F." (Bennet, *op. cit.*, p. 612). Lombard speaks of the climate of Biarritz as being a moist one, and Weber gives its relative humidity as about 80.0 per cent. This is no more than we should naturally expect in a place lying so directly upon the shore of the ocean, and so exposed to sea winds. "Biarritz," says Dr. J. Burney Yeo, "lies exposed to all the fury of the Atlantic winds, and has no protection like the pine forest of Arcachon" ("Health Resorts and Their Uses," London, 1882, p. 262). "The wind, when it blows from the southwest or northwest, is often furious" (Bennet, *op. cit.*). The annual rainfall is given by Weber as 49.21 inches. Concerning the rainfall during the winter season, we read in Dr. Bennet's book that "Dr. Chapman, an English physician, who long practised at Biarritz, states that the average rainfall during three years for the seven winter months, from the beginning of October to the end of April, was 25.81 inches on seventy-six days."

The sky at Biarritz is usually clear ("Dict. us. des sc. méd.").

Concerning the class of invalids likely to be benefited by a stay at Biarritz during the winter months, it may be said that in the main they would be such cases as would be improved, or it may be even cured, by residence at the not far distant resort of Arcachon, to which reference has already been made in this article. But it must be borne in mind that Arcachon, lying as it does some miles back from the Atlantic coast, surrounded by extensive sand dunes, and sheltered in some measure from the severity of sea winds by pine forests, is necessarily a somewhat dryer and a more protected spot than is Biarritz. Dr. J. Burney Yeo declares (*op. cit.*, p. 262) that the winter climate of Biarritz is "more bracing and less mild" than is that of Arcachon, and "is by no means so well suited to cases of chest disease." It is, however, he adds, "well suited to some forms of nervous exhaustion and irritability." Dr. Bennet speaks pretty much to the same effect concerning the climato-therapy of Biarritz. He considers the place far less suited to consumptive invalids than the dryer, milder, and more sheltered resorts lying along the Genoese Riviera and upon the Mediterranean coast of Spain, but regards it as probably quite as well, or even better adapted for such cases than are the famous resorts of the Isle of Wight and of other parts of the English south coast.

In conclusion, it may be remarked that over and above its excellent hotel accommodations, the neighborhood of Biarritz abounds in comfortable and attractive villas. often surrounded by gardens, and situated at various points close to, or even directly upon, its picturesquely rocky shores. *Huntington Richards.*

BIBIRU BARK.—*Greenheart Bark, Nectandræ Cortex.* The bark of *Nectandra Rodiæi* Schomb. (fam. *Lauraceæ*). This is a fine forest tree, with a tall, straight stem, attaining a height of twenty-five or thirty metres (seventy-five to ninety feet). It has thick, evergreen, coriaceous, oval leaves, and small axillary clusters of white flowers. The fruit is large, one-seeded.

The greenheart tree is a native of British Guiana, where it is highly prized as a source of the best ship timber. It was proposed as a febrifuge, and its alkaloid pointed out by Dr. Rodie, of Demerara, about fifty years ago.

The bark is imported in large, long, heavy, flat pieces, from 0.5 to 1 cm. in thickness (one-fifth to two-fifths inch). It is hard and brittle, breaking with a coarse, fibrous fracture; it is grayish brown externally, cinnamon brown and striated upon its inner surface. Its cells are seen under the microscope to be thickened, those of the liber curiously dentated. It has a strong bitter taste, *without aroma*—an unusual thing for any member of its family.

The bitterness of this substance is due principally to the alkaloid *buxine* (bibirine, bebeerine—not berberine), which it contains to the extent of one-half or one per cent. It also contains *nectandrine* and one or two other alkaloids, and tannin. The wood, which is also bitter, contains a base similar to that in the bark. The seeds are sometimes made use of as a source of starch. The impure buxine of nectandra is an article of commerce, and generally known as bebeerine. It is a gray or brownish, amorphous, bitter substance, permanent in the air, and very insoluble in water ($\frac{1}{6000}$). One or two of its salts, especially the sulphate and hydrochlorate, are also to be had, and should be preferred for administration on account of their free solubility.

The bark, and especially the alkaloid and its salts, has been offered, and to some extent employed as a febrifuge and antiperiodic; that is, as a substitute for quinine, but in reasonable doses they fall far short of that medicine for the purpose. They are, however, good simple bitter tonics (the bark is astringent as well). Doses: a useful dose of the bark would be large and disagreeable. Buxine or its salts may be given, as a tonic, in pills or solution, up to 2 to 4 dcgm. (0.2 to 0.4 = gr. iij. ad vi.); as a febrifuge, up to 1 or 2 gm. (gr. xv. ad xxx.).

W. P. Bolles.

BIG BONE SPRINGS.—Boone County, Kentucky.

ACCESS.—Viâ Louisville and Nashville Railroad to Walton; thence seven miles by stage to springs, or by steamer on the Ohio River to Hamilton Landing, thence one mile and a half to springs.

These springs are of the saline-sulphureted variety. No quantitative analysis has been made. It is stated, however, that the waters contain the following ingredients:

Sodium chloride.	Calcium bicarbonate.
Magnesium sulphate.	Magnesium bicarbonate.
Sodium sulphate.	Sodium carbonate.
Aluminum sulphate.	

There is also a large quantity of sulphureted hydrogen gas. *James K. Crook.*

BILE.—*Methods of Obtaining.*—Bile may be obtained for examination either from the gall bladders of men or animals after death or from biliary fistulæ.

The principal methods of establishing fistulæ in animals for experimental purposes are briefly as follows:

Permanent Fistulæ.—An incision is made over the gall bladder. Through this the common bile duct is tied in two places and a portion excised between the ligatures. The gall bladder is then sewed to the sides of the abdominal wound and opened.

Amphibolic Fistulæ.—The gall bladder is brought to the surface and opened as in the preceding method, but the bile duct is left intact. This method has an advantage over the other inasmuch as the external opening may be plugged and the bile allowed to follow its usual channels into the duodenum, or it may be left open, when the bile will flow externally, and, if not allowed to discharge for too long a time, will be more normal in character.

Temporary Fistulæ.—The common bile duct is exposed and opened, a glass cannula is tied in, and the bile is drawn off through a rubber tube attached.

Quantity of Bile Secreted.—The amount obtained through fistulæ is very variable in different animals, both absolutely and in proportion to the body weight. The rate of flow varies much in the same animal from hour to hour. In human subjects with biliary fistulæ the daily discharge has usually been between 400 and 900 c.c., and the total amount of solids between 5 and 20 gm.

Physical Properties.—Human bile as obtained from the gall bladder is usually of a yellowish or reddish-brown color, but when obtained fresh from a fistula is frequently green. Its reaction is faintly alkaline. The specific gravity varies from 1.005 to 1.010 or over in fistula bile, but is much higher in bile taken from the gall bladder after death, frequently reaching 1.030, or even 1.040. It has a bitter taste with a suggestion of sweet. Human bile has little or no smell; that of the ox and sheep has a faint musk-like odor. As secreted by the liver cells bile is non-viscous; but, during its stay in the ducts and gall bladder, it has added to it the secretions of their mucous membranes, containing mucin (human), or nucleo-albumin (ox), and it acquires a certain viscidity. On spectroscopic examination it may be seen to absorb the violet and some of the blue rays, but shows no definite absorption bands unless post-mortem changes have occurred.

Chemical Composition.—The principal constituents of bile are as follows; water, bile salts, bile pigments, mucin, fats and soaps, cholesterin, lecithin, urea (traces), and inorganic salts. Among the salts the most important are the chlorides of sodium and potassium and the phosphates of calcium, magnesium, and iron. The quantities of these constituents vary considerably, but the analyses contained in the following table may be taken as fair examples of a great number which have been published:

In 1,000 parts of bile.	Human gall-bladder bile. Frerichs. Man of 22 killed by violence.	Human fistula bile. Hammersten. One of three published in Hammersten's "Physiological Chemistry."
Water	859.2	974.6
Solids	140.8	25.4
Bile salts	91.4	9.04
Glycocholate	.....	6.86
Taurocholate	.....	2.18
Mucin and pigments	29.8	5.15
Fat	9.2	.61
Fatty acids from soaps	.....	1.01
Cholesterin	2.6	1.5
Lecithin	....	.65
Inorganic substances	7.7	7.46

The *bile salts* are the most abundant of the solid constituents and give to the bile its most important properties. The commonest bile salts, and those which have been most studied, are *sodium glycocholate* ($C_{26}H_{42}NaNO_6$), and *sodium taurocholate* ($C_{26}H_{44}NaNSO_7$), the former being most abundant in herbivorous animals and man, and the latter in carnivorous animals. The bile salts are soluble in water and alcohol, but insoluble in ether. If bile be mixed with freshly heated animal charcoal and evaporated to dryness, the bile salts may be dissolved out with absolute alcohol along with several other biliary constituents. If an excess of ether be now added, the bile salts alone are precipitated, forming "*Plattner's crystallized bile.*" Under the microscope this may be seen to consist of bell-shaped masses, star-like clusters of fine needles, or four to six sided prisms. Both the bile salts and their acids are dextro-rotatory to polarized light.

Sodium glycocholate	$(\alpha)\,D = +25.7°$
Glycocholic acid	$(\alpha)\,D = +29.0$
Sodium taurocholate	$(\alpha)\,D = +24.5$
Taurocholic acid	$(\alpha)\,D = +25.0$

In the intestines, the respective acids are set free from the bile salts and then further broken up into a complex non-nitrogenous acid, cholalic acid, and either glycocoll or taurine.

Glycocoll, glycocine, glycine, or amido-acetic acid ($NH_2CH_2.COOH$) is one of the products of the splitting up of sodium glycocholate. It is found free in the intestines in small quantities, and may combine in the body with benzoic acid to form hippuric acid, in which form some of it may leave the body by the urine, especially in the case of herbivorous animals. Glycocoll may be formed from the decomposition of proteids, and is in some cases a precursor of urea. It is probable, however, that glycocoll, taurine, and cholalic acid, when set free in the intestine from the decomposition of the bile salts, are reabsorbed, and combined once more in the liver to form a new supply of bile salts. This cycle of events is known as the "*circulation of the bile salts.*"

Taurine, amido-isethionic acid, or amido-oxyethylsulphonic acid ($NH_2.C_2H_4.SO_2.OH$), is obtained from sodium taurocholate. It differs from glycocoll in containing sulphur. Like glycocoll it is found free in the intestines in small quantities.

Cholalic, or *cholic acid*, ($C_{24}H_{40}O_5$), is set free, as stated above, when either sodium glycocholate or sodium taurocholate is split up, and it is found in the intestinal contents. Certain closely allied acids may replace it in the bile salts, among which the most important are *choleic acid* ($C_{24}H_{40}O_4$) and *fellic acid* ($C_{23}H_{40}O_4$), both of which have been obtained from human bile.

On the presence of cholalic acid depends Pettenkofer's well-known test for bile salts and bile acids.

Pettenkofer's test for bile acids is performed as follows: A small quantity of the solution to be tested, freed from proteids, is placed in a test tube, and two or three drops of a ten-per-cent. solution of cane sugar are added, and the whole shaken. Strong pure sulphuric acid is then added drop by drop, care being taken that the temperature of the mixture does not rise above 70° C. If bile acids are present the fluid first becomes opalescent, then the opalescence clears, and the liquid becomes successively of a pale cherry red, a dark carmine red, and finally a beautiful purple violet tint. The reaction sometimes takes a little time to develop, and it is wise to wait several minutes before drawing a negative conclusion. To make the test perfectly reliable, the colored solution obtained must be examined by the spectroscope, when two absorption bands will be found, one at F, and the other between D and E, near E. This is rendered necessary by the fact that a number of other substances, among which are proteids, oleic acid, amyl alcohol, morphine, and numerous aromatic substances, give a similar color reaction, but may be distinguished by causing different absorption bands.

The Bile Pigments.—The pigments constantly found in human bile are bilirubin and biliverdin.

Bilirubin ($C_{16}H_{18}N_2O_3$) has also been called cholepyrrhin, biliphæin, bilifulvin, and hæmatoidin. It occurs in the biles of all vertebrates, but is most abundant in those of carnivora and man, giving them their yellowish or reddish-brown color. It may be obtained as an amorphous powder, and also as reddish-yellow rhombic plates. It is readily soluble in chloroform, less so in al-

cohol, and still less so in ether. It is insoluble in water, and exists in bile as a soluble calcium compound, known as bilirubin-calcium. It forms a considerable part of some gall stones, and is present in the blood serum of certain animals (horse), in old blood extravasations, and in the tissues and urine of cases of jaundice. It is derived from the hæmoglobin of broken-down red corpuscles, and is the probable source of the stercobilin of the fæces and of the urobilin of the urine, which are believed now by some to be identical with each other. Under the influence of oxidizing agents bilirubin is converted into biliverdin.

Biliverdin ($C_{16}H_{18}N_2O_4$) is present in all green-colored biles, among which are to be included those of the herbivora and some examples of human. When obtained pure, it usually consists of a dark green amorphous powder, but occasionally crystallizes in green rhombic plates. It is insoluble in water, ether, and chloroform, but soluble in alcohol, glacial acetic acid, and strong sulphuric acid. It is converted by reducing agents into bilirubin, and this change often occurs in the human gall bladder, which explains the fact that bile obtained from that source after death is nearly always of a reddish-brown color, while fresh fistula bile is frequently green.

Hydrobilirubin ($C_{32}H_{40}N_4O_7$), a reduction product of bilirubin, may be formed from it in the laboratory, and is regarded by some as supplying a link between the pigments of bile and those of the fæces and urine.

Tests for Bile Pigments.—Gmellin's test. Spread out a few drops of the suspected liquid on a white plate. Let a drop of fuming nitric acid (containing nitrous acid) fall in the centre. If bile pigments be present a ring of colors, green, blue, violet red, and yellow, will appear. This is due to the oxidation of the pigments, by which bilirubin is changed successively into biliverdin (green), bilicyanin (blue), bilipurpurin (violet red), and choletelin (yellow). The blue pigment bilicyanin, in acid solution, gives a spectrum with two absorption bands, one on either side of the D line, which fuse into one if the solution be very strong. The yellow choletelin gives a single band between b and F, nearer to F.

Huppert's Test for bilirubin. Add to the suspected liquid, milk of lime till a precipitate (bilirubin-calcium) is thrown down. After washing this precipitate in water, place it in a test tube, and half fill the test tube with alcohol acidified with hydrochloric or sulphuric acid. Boil for some time, and if the original liquid contained bilirubin, an emerald green or bluish-green color will develop.

Mucin.—As already mentioned, the mucin present in human bile is largely derived from the secretions of the bile ducts and gall bladder. In many animals it is replaced by nucleo-albumin. These substances resemble each other in their viscidity, and are both readily precipitated from bile by acetic acid, but differ in the products of their decomposition. Mucin splits up into a proteid and a carbohydrate; nucleo-albumin, on the contrary, into a proteid and a complex nitrogenous substance, rich in phosphorus, known as nucleic acid.

Fats.—These consist principally of palmitin, stearin, and olein, with the corresponding soaps.

Cholesterin is a complex monatomic alcohol. Its chemical formula is not yet absolutely agreed upon, but is probably $C_{27}H_{45}OH$ (Obermüller). It is present in nearly all animal tissues, especially those of the central nervous system. It is insoluble in water, but freely soluble in ether, chloroform, and hot alcohol. It crystallizes out from alcoholic solutions in colorless transparent plates. From anhydrous ether or chloroform it separates in the form of needles.

Lecithin ($C_{42}H_{84}NPO_9$) is found along with cholesterin in nearly all animal tissues. It yields on decomposition glycerin, a fatty acid, phosphoric acid, and an alkaloid known as cholin.

Action of Bile.—Bile is partly an excretion, and partly a secretion playing a part in digestion and absorption. Its digestive properties depend almost entirely on the presence of the bile salts. In some animals traces of diastatic ferment have been found, but never in sufficient amount to play any important part in digestion. The principal action of bile is on the fats, and depends on the fact that solutions of the bile salts have the power of dissolving free fatty acids. Now the present tendency is to the view that fats are absorbed as fatty acids and soaps, in solution, rather than in the form of emulsion. If this be so, the part played by the bile is very important. After the neutral fats are split up by the pancreatic juice into glycerin and fatty acids, the latter are dissolved by the bile and partly converted into soap by its alkaline salts. Moreover, bile is able to dissolve the soaps of the alkaline earths (calcium) which would otherwise be insoluble. There is an old view, that the bile also exerts a favorable influence on the absorptive functions of the intestinal wall; but, as this has been noted especially in the case of fats, there is little doubt that it depends simply on its power of dissolving them.

The function ascribed to it of preventing putrefaction in the intestine is, no doubt, also to be explained by its aiding fat digestion so that the fatty food is absorbed before it has had time to undergo putrefactive change. Then it must be remembered that the absorption of the fatty portions of the food will expose the other constituents better to the action of the pancreatic juice, so that all the digestive processes will proceed more rapidly.

Lastly, there is satisfactory experimental proof that the several ferments of the pancreatic juice are most active in the presence of bile, although just how it favors their action is not fully explained.

Biliary concretions or gall stones may be divided into two principal types:

1. Dark-colored, hard, non-inflammable stones, consisting principally of calcium compounds of the bile pigments (especially bilirubin-calcium) and calcium carbonate.
2. Lighter-colored soft stones, which will melt and burn in a flame, and consist very largely of cholesterin.

Other constituents often found in gall stones are: bile acids, free bilirubin, phosphates of lime and magnesium, sulphate of lime, sodium, potassium, copper, manganese, silicic acid, mucin, and epithelium. Most gall stones are intermediate in composition and properties between the two extreme types given above, and vary in color from nearly white, through golden or greenish yellow, to reddish brown and black. Many stones vary in color and composition in different layers.

Among possible causes which have been suggested for gall stones the following may be mentioned:

1. Excess of lime and deficiency of sodium salts in the bile, leading to precipitation of the pigments.
2. Presence of chronic catarrh, leading to excessive secretion of mucin.
3. Excess of cholesterin in the blood as a result of excessive brain work, old age, or other causes.
4. Concentration of the bile from stagnation.
5. Naunyn's theory, which now receives much support, combines several of the above, and may be briefly stated thus:

Gall stones are the result of a pathological alteration in the mucous membrane of the gall bladder, usually excited by the presence of microbes, and leading to an increased excretion of lime and cholesterin.

T. Wesley Mills.
William S. Morrow.

BILE PASSAGES. See *Gall Bladder* and *Liver.*

BILHARZIA HÆMATOBIA. See *Trematoda.*

BILIRUBIN. See *Coloring Matters, Animal.*

BIOLOGY.—(*βίος*, life, and *λόγος*, a discourse.)

DEFINITION.—"The subjects of our inquiry will be the various forms and phenomena of life, the conditions and laws under which this state occurs, and the causes through which it is brought about. The science that occupies itself with these subjects we will designate by the name *biology*, or the science of life." This, in translation, is

the definition of biology given by Treviranus in 1802, and it applies equally well to-day.

The term has not always been used with this meaning, however. The Oxford Dictionary gives three ways in which it has been employed.

(1) It was used in England for the first time by J. Stanfield * in its true etymological meaning to designate "the study of human life and character," as distinguished from biography, the history of the lives of individual men.

(2) The unfamiliarity rather than the etymology of the word probably accounts for a use that appears to have arisen in this country. The writer has heard it stated by the president of the Johns Hopkins University that when it was proposed to establish there a biological laboratory in 1876 the name "biological" was regarded with suspicion as suggestive of the fakir. This was because, as stated by W. B. Carpenter: † "About the year 1850 'the world was turned upside down' by a couple of itinerant Americans, who styled themselves 'professors' of a new art which they termed *electro-biology;* asserting that, by an influence of which the secret was known only to themselves, but which was partly derived from a little disc of zinc and copper held in the hand of the 'subject' and steadily gazed on by him (whence the designation which they adopted), they could subjugate the most determined will, paralyze the strongest muscles, pervert the evidence of the senses," etc. "Electro-biology, or '*biology*' (as it came to be very commonly designated) was not merely introduced at scientific reunions, but became a fashionable amusement in some circles, at ordinary evening parties, and thus it happened that a large proportion of the public became familiarized with the phenomena." "Professed biologists" gave public exhibitions, and Carpenter himself speaks of "the biologized subject" and of "biological phenomena," meaning thereby what we now understand by hypnotism.

(3) Fortunately that use of the word has become obsolete, and biology is employed at the present time in both popular and scientific language with the meaning originally given to the word by Treviranus in the passage quoted at the beginning of this article.

History of Biology.—Biology is relatively a new science. The famous Roman naturalist Pliny embraced within his "Natural History" all realms of nature, including man and his activities. But as the result of the theological ideas of the Middle Ages, man became to be regarded as something apart from nature. Thus Lord Bacon ‡ divides the descriptive sciences into history of nature and history of man, and the knowledge of causes into divine philosophy, natural philosophy, and human philosophy; but all divisions of knowledge, he said, are like the branches of a tree that meet in a stem.

Gradually as the mass of human knowledge grew and became more classified, various branches were split off from natural history, such as astronomy and physics, which, because they dealt more with the causes than with the descriptions of phenomena, were called natural philosophy, using Bacon's term in a somewhat different sense. Later chemistry, emancipated from the mysticism of alchemy, became a distinct science, and the name natural history was restricted to the sciences that appeared to be purely observational.

Buffon, writing in the middle of the eighteenth century, divided all science into civil history and natural history. But his natural history was essentially descriptive and was divided into three sections dealing with animals, plants, and minerals. He recognized, however, a unity in nature so that one may descend by nearly insensible degrees from the most highly organized animal to the simplest mineral; and he regarded man as the animal which occupies the highest point in his scale.

Bonnet, in his "Contemplation de la nature" (1764), goes one step farther than Buffon by saying, after making an extended comparison, that animals and plants are only modifications of organized matter. He described an animal as an organized being which is nourished by internal roots, and a plant as one in which the roots are placed outside. They are nevertheless essentially the same, he says, and the character by which they may be truly distinguished is unknown to us.

It remained for Bichat, in 1801, to draw a clear distinction between organic and inorganic beings, between physiological and physical sciences. He based his distinction upon the possession, by organic beings, of the properties of irritability and contractility.

In the following year (1802) the term biology was proposed by Treviranus and Lamarck to cover what Bichat called the physiological sciences. Whether the word was coined independently by these two writers as supposed by Geddes, or whether it was borrowed by Lamarck from Treviranus, as stated by Littré, is not important. In any event, the chief credit is due to Treviranus, for he not only invented the name, but he set to work earnestly to erect the science that it was intended to designate, publishing his results in a book of six volumes entitled "Biologie, oder Philosophie der lebenden Natur." But, unfortunately for his success, the foundations upon which he had to build—systematic zoology and botany, morphology, physiology, and general anatomy—were only then being established. Not only were these sciences incomplete as to matter, but, as he says, they were then as isolated as the pyramids in the sands of Egypt. Nevertheless, he succeeded in producing what Huxley has well termed a very remarkable book, one that is essentially modern in its plan and execution; very different from the work of his countryman Oken, which, although more highly regarded at the time, would now be considered mediæval rubbish.

Treviranus was seriously hampered in his treatment of the subject by the fact that the two great generalizations which were to furnish the true scientific bases for the unification of the biological sciences had not then been formulated. These were: the cell theory, propounded by Schleiden and Schwann in 1838; and the theory of the origin of species by means of natural selection, published by Darwin and Wallace in 1858. Thus it happened that, while the point of view of Treviranus was appreciated and upheld by a few such men as Auguste Comte and Isidor Geoffroy Saint-Hilaire, and others were by their contributions to knowledge helping, perhaps unconsciously, to confirm it, the great majority of zoologists, botanists, anatomists, and physiologists failed to look beyond the confines of their special provinces.

By the publication of the "Origin of Species" a new light was thrown upon organic nature which not only showed the essential unity of the animal and vegetable kingdoms, including mankind, but also, by eliminating the supernatural factor, served to bring biology into harmony with the other natural sciences. Under the leadership of Herbert Spencer and Huxley in England and of Haeckel in Germany this new point of view has been widely propagated until now in many colleges and high schools a student may get his first introduction to natural science through a course in general biology.

The Living Substance.—Since its publication in 1838 the cell theory has been greatly modified by the researches of Max Schultze and many other investigators. At the present time one of the chief reasons for the union of botany and zoology in a single science called biology is found in one of the generalizations of the cell theory as now accepted—namely, that the physical basis of life, the living substance, or *protoplasm*, has certain fundamental characteristics which are essentially the same wherever it may be found.

(1) *Occurrence.*—In the first place, the living substance always occurs in certain definite aggregates, that we call *organic individuals.* To be sure, many non-living substances may also occur in aggregates with a definite form —that is, in crystals. But the crystal differs from the organic individual in many important particulars. A crystal of sodium chloride may be crushed, or even dis-

* Stanfield, J.: "Biography," 1813, p. 12.

† Carpenter, W. B.: "Principles of Mental Physiology," New York, 1870, p. 550.

‡ "Advancement of Learning," 1605.

solved, but its substance still remains sodium chloride. On the other hand, a blow on the head is sufficient to convert a living ox into dead beef. As the result of an injury to a part, the whole aggregate has ceased to be living substance and has become a mere mass of proteids, fats, and salts. But what is the difference between the living and the dead ox? Its form and proportions remain the same. It has not lost weight, and we may infer from this that a chemical analysis of the carcass will enable us to ascertain the kind and proportion of the chemical elements that were present in the living body; although we shall still be ignorant as to what rearrangements of these elements may have taken place in the course of death.

(2) *Activities.*—The great difference between the dead and the living, then, is not in form or substance but in activity. If we beat the dead ox, it will not move away; if we place hay and grain in its stomach, it will not be dissolved and converted into ox-stuff. Just as the ox differs from the salt and the beef that I am to have for dinner, so the living oak tree differs from the crystal on the one hand and from the wood of my table on the other. The wood can no longer take in carbon dioxide and oxygen from the air, water and salts from the ground, and convert them into oak-stuff. Neither can it respond to the stimuli of light or gravity. What is true of the ox and the oak is true of animals and plants in general, and thus we find certain powers of activity which they possess in common and which distinguish living beings from all other bodies. These may be summarized as follows:

(*a*) *Assimilation.*—This is defined by Verworn as "the sum of the processes that lead to the construction of living substance to the maximum of its most complex constitution, the synthesis of proteids."

In these processes various non-living substances are brought into contact with the protoplasm and are there converted into living substance like itself.

(*b*) *Dissimilation.* — Hand-in-hand with assimilation goes the reverse process, dissimilation, the giving off of non-living material, waste products, from the living substance. Assimilation and dissimilation, anabolism and katabolism, are two phases of *metabolism*, a process that is continuous in a living organism. Its cessation, however, does not necessarily imply death, for it has been shown that there is no metabolism in seeds that are dried but which are still capable of germination under proper conditions. Moreover, as Verworn has pointed out, the process is not without its analogy in inorganic chemical processes. In the manufacture of sulphuric acid, the nitric acid which is used, or rather the nitroyl-sulphuric acid formed during the reaction, is continually being built up and broken down, so that if fed with a continuous supply of sulphurous anhydride, water, and oxygen a small amount of nitric acid may produce an unlimited quantity of sulphuric acid, without any diminution of its own substance. Similar phenomena may be observed in Deacon's process for the manufacture of chlorine, and in other chemical operations in which catalytic substances are used.

Nevertheless metabolism, and especially its constructive phase, assimilation, is a process that is highly characteristic of a living being, and is not ordinarily met with elsewhere in nature.

(*c*) *Growth.*—Whenever assimilation exceeds dissimilation, increase in size, or growth, of the organism takes place.

(*d*) *Reproduction.*—Growth leads to reproduction, or the separation from the organism of a part of the living substance to form a new organism like the parent.

(*e*) *Irritability.*—This has been defined as "the capacity of a body to react to an external influence by some kind of change in its condition, in which the extent of the reaction stands in no definite proportion to the extent of the influence." This highly characteristic property is possessed by all living substances. It finds its analogy, however, in certain non-living substances, the explosives. But there is one difference between the explosion of an unstable chemical compound and the reaction of an organism to a stimulus. The explosion results in the destruction of the mass, while an organic reaction is normally purposeful in character and tends to the preservation of the mass.

(3) *Structure.*—While it is possible to find some analogy between the activities of protoplasm and other processes in nature, there are certain minute structural features to be found in substance that is living, or has lived, for which we may look elsewhere in vain. The fundamental generalization of the cell theory is that every animal or plant is a cell, or a collection of cells and their products. A cell may be defined as a mass of protoplasm with its contained nucleus. It is found by experiment that if a portion of the protoplasm be separated from the nucleus, it may still respond to stimuli, but it can no longer assimilate food or repair damage. It has lost the power to perform some of the essential vital functions. Likewise a nucleus deprived of its surrounding protoplasm, or cytoplasm, is incapable of continuing life. Thus we are led to regard the cell as the unit organism, and its structure as a fundamental characteristic of the living substance.

As to the ultimate structure of protoplasm, there has been great diversity of opinion. The best view appears to be the one recently expressed by Wilson, that in its simplest form the structure of the protoplasm is like that of an emulsion, in which the continuous substance is the active living material, and the inclusions, ranging in size from the largest yolk granules to bodies at the limit of microscopic vision, are passive materials in various stages of metabolism. But, superimposed upon this vesicular structure, there may be also a fibrillar structure (see *Cell*). It may be noted that while the complex organization of the cell is characteristic of the living substance, the more minute vesicular structure of protoplasm has been shown by Butschli to have an analogy in the structure of certain inorganic colloidal substances.

(4) *Chemical Composition.*—It is in their chemical composition that Verworn finds what he regards as the one fundamental character that all animals and plants have in common and that distinguishes them from all other bodies. This characteristic is the possession of a class of highly complex compounds of nitrogen, carbon, hydrogen, oxygen, and sulphur known as the proteids. Both fats and carbohydrates also occur very generally in animals and plants, and with the proteids form their chief constituents. That all three classes of compounds are found in the living as well as in the dead cell is shown, according to Verworn, by "a careful comparison especially of the solid bodies that may be found as reserve substances for a time unchanged in the living cell, with the corresponding substances of the dead cell." Nevertheless, there are differences between living and dead protoplasm that show that death involves a chemical change. In the first place, living protoplasm usually has an alkaline reaction or is neutral, while dead protoplasm is generally acid. Then there are certain proteids that are fluid in life and coagulated at death. The difference is again shown by the effects of diamid and hydroxylamine. These substances are strong poisons, that is, they destroy living protoplasm, producing presumably substitution products; but they have no effect upon dead protoplasm. Moreover, while alive, protoplasm is continually undergoing change, taking up oxygen and giving off various products of metabolism, but when dead it is stable, and under certain conditions may remain unchanged for years. So while it is true that the three classes of compounds characteristic of dead protoplasm are found also in that which is living, they do not have exactly the same chemical composition. Therefore a chemical analysis of dead protoplasm will not reveal the exact chemical constitution of the living substance.

(5) *Origin.*—Finally the living substance, whether it be animal or vegetable, differs from all other substances in its mode of origin. Other chemical compounds may be formed anywhere that the necessary elements are brought together in favorable combinations and under the right conditions of temperature, solution, etc. We

know nothing in regard to the conditions under which living matter was first produced, and we are equally ignorant as to what future discovery may bring forth; all we know at present is that the living substance appears to be peculiar in that the only conditions under which it can be produced are those found in the living organism, animal or plant as the case may be. Lifeless material is converted into living substance only by the process of assimilation. This takes place only in the presence of pre-existing living substance. This great generalization, called by Huxley the doctrine of *biogenesis*, is due to the labors of Redi, Pasteur, and their successors; and is the fundamental fact upon which is built the modern practice of aseptic surgery.

Other Points of Agreement between Animals and Plants.—If the fundamental similarities between animals and plants that have just been enumerated are not deemed sufficient to establish the union of the biological sciences, we may seek further into the details of the structure and vital processes in organisms, and there we shall find still more striking evidence of their essential unity.

Not only does the definition of a cell as a mass of protoplasm surrounding a nucleus apply equally well to multicellular animals and plants and to the unicellular organisms, classed by Haeckel together under the name Protista; but we find that certain details of structure are always found in cells wherever they may occur. This applies more especially to the nucleus, which ordinarily in the resting condition is a rounded sac-like body surrounded by a delicate membrane. Within these is a structure usually described as a reticulum, but more probably an alveolar structure, consisting of two substances, *linin* and *chromatin*, while the spaces within the alveoli or reticulum are filled by a clear *nuclear sap*. Even in bacteria and other micro-organisms which do not possess a well-defined nucleus, granules are found scattered about in the cell which are probably chromatin.

Cell division in both animals and plants is always preceded by the division of the nucleus, which usually takes place by what is called the indirect method (*karyokinesis*, or *mitosis*). The essential thing in this method is the exactly equal division of the chromatin (see article *Chromosome*).

In both animals and plants increase in the number of individuals may take place by three methods of reproduction—fission, budding, and sexual reproduction (*gamogenesis*). Sexual reproduction differs from the other modes in that the new individual arises from a cell that is derived from the union of two cells usually having origins in different individuals (see *Sex*).

In both animals and plants the cells that are to take part in sexual reproduction undergo a preparatory change which results in a reduction in the amount of chromatin; and even in the unicellular organisms in which the sexes are not differentiated a similar process is found to occur (see *Reduction Division*).

In the union of two cells to form a germ (oöspore) the essential process is the union of the two nuclei. While the details of this process differ in different species, it always results in the formation of a nucleus in which the chromatin is derived in exactly equal parts from the male and the female parent. In the conjugation of the unicellular organisms, even where there is no union of the cell bodies, there is formed likewise in each individual a new nucleus to which each one has contributed just half of the chromatin (see *Impregnation*).

Differentiation of structure goes hand-in-hand with division of labor. It may occur within a single cell, resulting in the specialization of different parts of the cell to perform different functions; or, in multicellular organisms, it may cause whole cells or large masses of cells to differ from others, forming tissues and organs for various functions. In both animals and plants the causes of differentiation may be divided into two classes. One depends upon the structure or chemical composition of the protoplasm itself, the other depends upon the external conditions surrounding the organism (see *Differentiation*).

In the developing organism differentiation is followed by growth, which takes place according to the same laws in both animals and plants (see *Growth*).

In both animals and plants the offspring tends to resemble its parents at the corresponding stages of growth. This is not merely the result of development under similar external conditions. A change in the environment will result in a change in the organism; but you may change the environment as much as you please and still you cannot cause the egg of a star-fish to develop into a sea urchin, or *vice versâ*. Embryos of two species may be reared under perfectly identical conditions, yet each one will come true to its kind. This tendency among organisms for like to produce like, depending upon something in the structure of the germ, is what we mean by *heredity*. The researches of Galton, Pearson, and others show that the laws of heredity among animals apply equally well to plants (see *Heredity*).

Finally we are indebted to Charles Darwin for the discovery of the principle of *natural selection*, which is equally applicable to animals and plants as an explanation of the phenomena of diversity, or the origin of species (see *Evolution*).

A measure of the advance made in general biology during the last one hundred and fifty years may be obtained by comparing such a list of the similarities of animals and plants as that given in the preceding paragraphs with the discussion of the same subject to be found in the second part of Bonnet's "Contemplation de la nature," published in Amsterdam in 1764.

Divisions of Biology.—Biology has been divided into subordinate sciences without number. For example, we have carcinology, the study of crabs; conchology, the study of molluscs; mycology, the study of fungi; recently cytology, the study of cells, etc.—each separate group of organisms or organs having its own special "ology." These subjects may be arranged in groups from several different points of view. The biological sciences may be divided into two great groups, *botany* and *zoology*, dealing respectively with plants and animals. Or we may distinguish between organisms now living and those known only by their fossil remains. Then we have *recent biology* and *palæontology*. Again, from normal biology we may separate the study of the abnormal conditions of organisms, *pathology*. Finally, and this seems to be the best arrangement, we may follow Huxley and divide *biology* into four great groups, —*morphology*, *physiology*, *chorology*, and *ætiology*. The relations of these sciences are exhibited in the accompanying scheme (Fig. 481).

Morphology (μορφή, form) is the study of the structure of organisms. It includes *general anatomy*, or *histology*, the study of the microscopic structure of cells, tissues, and organs; *anatomy*, which may be purely descriptive, as human anatomy; or comparative, when it has for its aim the discovery of homologies; *ontogeny*, including embryology, the study of development within the egg, and the study of post-embryonic development and metamorphosis. The facts of anatomy and development form the basis for the classification of organisms, which is treated under *taxonomy*.

Another branch of morphology is *pathological anatomy*, dealing with the histology and gross anatomy of diseased tissues and organs. *Palæontology* includes the morphology of fossil organisms, although this term is generally restricted to the morphology of fossil animals, while palæobotany is used for plants.

Physiology (φύσις, nature), on the other hand, has to do with the functions of organisms, more especially the activities of the cells, tissues, and organs. These may be divided into *generative*, including the phenomena of reproduction; *sustentative*, including digestion, absorption, circulation, and the complex phenomena of metabolism and secretion; *correlative*, including the relations between stimuli and reactions, and the physiology of the muscular and nervous systems. The study of the perturbations of these functions under diseased conditions gives us *pathological physiology*. Partly physiological and partly

morphological is the study of the phenomena of growth differentiation, heredity, and variation. These subjects may be classed together as *morphological physiology*, or *experimental morphology*.

Chorology (χώρα, dwelling place, area of distribution) is a term invented by Haeckel to include all the phenomena of distribution of organisms. These may be studied from three points of view, geographical, topographical, and geological, the later giving an account of the succession of forms in geological history.

Ætiology (αἰτιολογία, giving a cause) is a term long used by physicians to designate the study of the causes of disease. Originally, however, it had a broader meaning,—the study of causation in general. It is in this sense that Huxley has borrowed the term and used it to designate the group of biological sciences which have for their aim the explanation by general physical laws of the origin and present condition of living beings upon the globe. This includes *ecology* (οἶχος, household), the science dealing with the total relations between organisms and the surrounding outer world; also called bionomics, and including most of what is popularly meant by natural history. The facts of morphology, physiology, and distribution, as well as those of ecology, all contribute to the theories of *evolution*, whereby it is sought to explain the origin of species; and from the study of fossil remains, aided by comparative anatomy and embryology, it is possible to form a conception of the *phylogeny*, or history of the changes which the various groups of animals and plants have undergone in the ages that are past.

Psychology and *sociology* are not usually regarded as parts of biology, and, as Huxley has remarked, the biologist has already quite enough to do without including these sciences within his field of study. Nevertheless the mental activities which form the subject-matter of psychology are after all only certain special functions of the brain, and as such their study becomes only a subdivision of the physiology of the nervous system.

Sociology likewise deals with a series of phenomena with which the biologist, as a rule, has nothing to do. But, on the other hand, the relations of men in a commonwealth do not differ essentially from those of bees in a hive; and from this more general point of view the study of these relations might be regarded simply as a special branch of ecology. *Robert Payne Bigelow.*

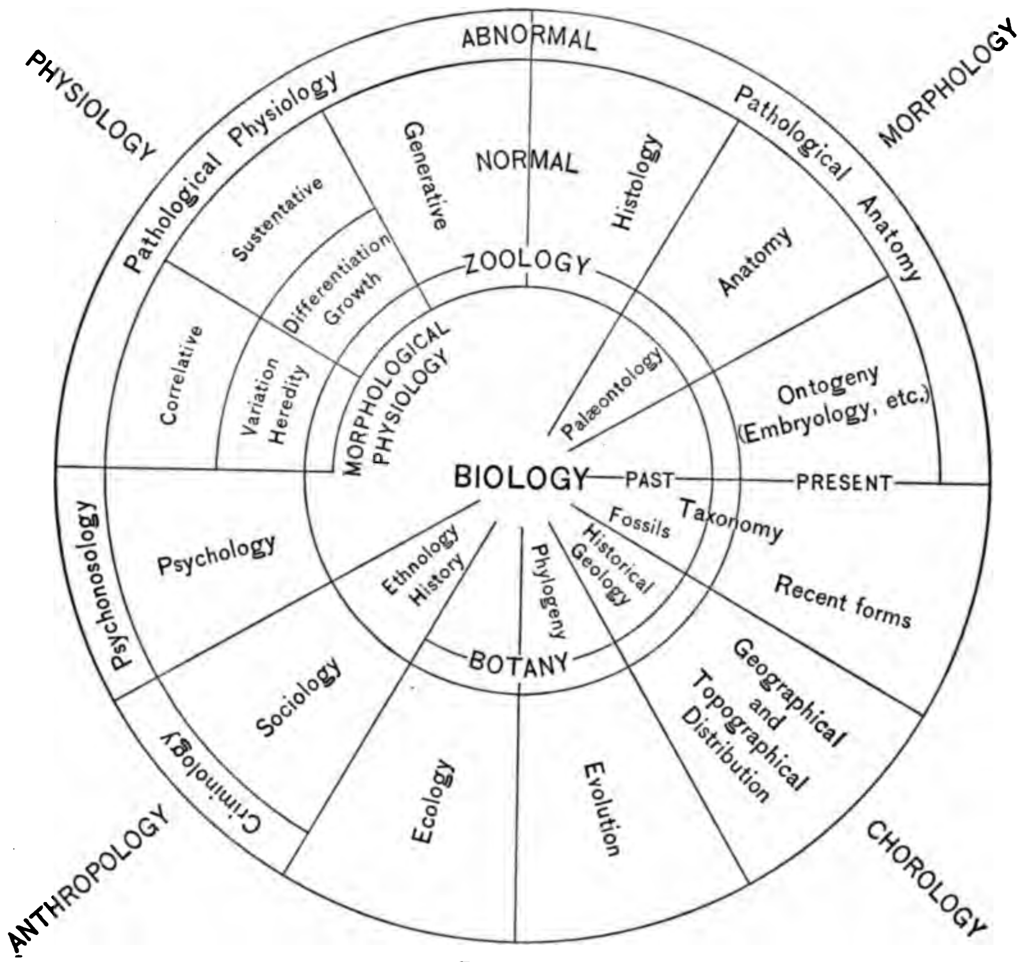

FIG. 481.

LITERATURE.

The literature of biology is already enormous and is growing larger every year. It may be well, however, to mention here a few useful works of reference.

For a brief history of biology see J. A. Thomson: "The Science of Life," 1899.

Good elementary treatises on general biology are Huxley and Martin: "Practical Biology"; T. J. Parker: "Lessons in Elementary Biology"; and Sedgwick and Wilson: "General Biology," second edition.

More extended treatment of general problems will be found in E. B.

Wilson: "The Cell in Development and Inheritance," second edition; M. Verworn: "General Physiology," translated by Lee; C. B. Davenport, "Experimental Morphology"; Y. Delage: "La structure du protoplasma et les théories sur l'hérédité et les grands problèmes de la biologie générale"; C. L. Morgan: "Animal Life and Intelligence."
For philosophical discussion see H. Spencer: "Principles of Biology," second edition, 1900; W. K. Brooks: "The Foundations of Zoology"; K. Pearson: "The Grammar of Science," second edition, pp. 328–532.
Additions to the science are recorded annually in L'Année Biologique, edited by Delage, Paris, since 1895; and in "Ergebnisse der Anatomie und Entwickelungsgeschichte," edited by Merkel and Bonnet, Wiesbaden, since 1891.

BIOPLASSON—a term introduced by Elsberg for the protoplasm. In consequence of the observation of the intercellular bridges by which the protoplasm of adjacent cells is in many tissues connected, Heitzmann has denied the existence of cells and has asserted that the body consists of a network of protoplasm. Elsberg adopted this strange theory and introduced bioplasson for protoplasm, a term which it is necessary to note only because it is used by a small circle of American writers. Heitzmann's theory has also been advocated by Adam Sedgwick, who has attempted accordingly to revolutionize all morphological conceptions. That Heitzmann's theory is erroneous, on account of its evident exaggeration, hardly needs demonstration. That fine protoplasmatic bands connect the adjacent cells of certain tissues, both in plants and animals, is now well established; but this does not in any way invalidate the cell doctrine. Even if it were true, which it is not, that, as Heitzmann apparently claims, all tissues consist of a network, this would not do away with cells as the unit of organization. The fatal objection to Heitzmann's view, however, is the fact that the union of cells is secondary, for during the segmentation of the ovum the cells are completely separated, and the connection between them does not exist until considerably later in the course of development. What Heitzmann considers as primary is therefore secondary; his theory has been almost unanimously rejected by histologists. *Charles S. Minot.*

LITERATURE.

Elsberg: Notice of the Bioplasson Doctrine. Trans. Amer. Med. Assn., 1875.
Heitzmann: Microscopical Morphology, 8vo, New York, 1883. (Presents Heitzmann's theories *in extenso*, but displays a strange disregard of contemporary research.)
Sedgwick, Adam: On the Inadequacy of the Cellular Theory of Development, etc. Quart. Journ. Microsc. Sci., xxxvii., p. 87, 1894.

BIRCH.—The common name of the genus *Betula* (fam. *Betulaceæ*), of some thirty-five species, several of which are strongly aromatic. Unless otherwise specified, the *B. lenta* L., Sweet Birch or Cherry Birch (incorrectly "Black Birch") is to be understood. This is an abundant shrub or small tree in Eastern North America. Its bark is an important article of commerce, and has long been used medicinally as well as for flavoring. It contains a volatile oil identical with that of wintergreen, which see.

The wood of several species is used as a source of medicinal tar, which, like that of beechwood, is rich in guaiacol. *Henry H. Rusby.*

BIRCHDALE SPRINGS.—Merrimac County, New Hampshire.

POST-OFFICE.—Concord. Hotel.

These springs are located about four miles from the state house. The springs are four in number, known as the "Concord," "Merrimac," "Granite," and "Penacook." The following analysis of the Concord was made in 1873 by Prof. Charles F. Chandler, of New York:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium bicarbonate	.19
Calcium bicarbonate	2.09
Magnesium bicarbonate	.84
Iron bicarbonate	.37
Sodium chloride	.38
Sodium sulphate	.26
Potassium sulphate	.07
Sodium phosphate	.01
Silica	.92
Alumina	.12
Organic matter	.67
Total	5.92

We have been unable to obtain information relating to the present status of these springs. They were formerly used both commercially and as a resort.
James K. Crook.

BIRTHS, STATISTICS OF. See *Vital Statistics.*

BISKRA—a place of growing importance—is situated on the outskirts of the Algerian Sahara, at an elevation of about three hundred and sixty feet above sea level, in Lat. 35° 27' N., and Long. 3° 22' E. It consists of a union of several villages containing in all eight thousand inhabitants. It lies among plantations of date palms and evergreen trees, with gardens and squares containing tropical plants such as the yucca, the false pepper plant, the fragrant gum trees and palms. Nearby are mountains capped with snow for the greater part of the year, and to the south the limitless expanse of the desert. Biskra is reached by steamer from Marseilles to Algiers in twenty-six hours, and by rail from the latter place in two days. One can break the journey at Constantine, which is about half-way. There are good hotel accommodations, and one can find endless diversion in the Oriental life and scenes of the various tribes which collect here—the shepherd Arab, the Nomads, the Moor, and the African. There are also to be found numerous remains of Roman occupation. The water supply is derived from wells, one of which, in the great mosque, is said never to be dry. According to Weber and Foster (Albutt's "System of Medicine," 1896), the water contains too much salt for drinking and for certain cooking purposes.

The climate partakes of that of the desert, being warm, dry, equable, sunny, and rather bracing. "It is much drier and sunnier than the neighborhood of Algiers itself; but it is subject to violent winds which for days together may prevent outdoor exercise" (Weber and Foster). The season extends from October to April, and the temperature for these months, for the years 1887 to 1891, is given by Hurabielle ("Biskra," Paris, 1899) as follows:

	Maximum.	Minimum.	Mean.
October	81.2° F.	58.6° F.	70.0° F.
November	69.0	48.0	57.9
December	60.5	42.0	50.8
January	58.6	39.7	48.8
February	62.0	42.0	52.6
March	77.5	48.4	59.3
April	77.7	54.0	66.0

The following comparison is made with the temperature of Nice:

	Maximum.	Minimum.	Mean.	Rainfall.
Nice	67.7° F.	36.8° F.	52.0° F.	3.9 inches.
Biskra	60.5	47.6	58.4	0.6 inch.

The rainfall is almost *nil*, and the relative humidity must be very small. We have then at Biskra, during the winter season, or from October to April inclusive, a dry pure atmosphere, a mild and very equable temperature, practically no rain, and almost constant sunshine. "For six months," says Murray, "the climate is delicious. In the whole of Algeria one does not find a more agreeable temperature, a clearer sky, or more beautiful vegetation." The most considerable drawbacks are the high winds from the south and west, which are frequent. One is, however, partially protected from them in the interior of the oasis by the forest of date palms, which covers an area of twelve thousand square metres.

The diseases which are relieved by a residence in this climate are certain cases of pulmonary tuberculosis, albuminuria, rheumatism, neurasthenia, climacteric disturbances, etc. There is no evidence that malaria exists at Biskra.

The writer would acknowledge his indebtedness in the preparation of this sketch to J. Madison Taylor's article "Biskra," in the *Climatologist* for 1891; to "Au pays du bleu," Biskra, par L'Abbé Jean Hurabielle, Paris, 1899; and to the article upon "Climate in the Treatment of Disease" in Albutt's "System of Medicine," 1896.

Edward O. Otis.

BISMUTH.—1. General Medicinal Properties of Compounds of Bismuth.—Experiments upon animals have shown that impregnation of the blood with bismuth produces poisonous effects generally similar to those wrought by other heavy metals. So far, however, as concerns the compounds of bismuth used in medicine, these, if pure, can be given with great freedom without constitutional disturbance—a fact commonly, and probably correctly, accounted for by the great insolubility of these compounds, by reason of which absorption of the mineral is both feeble and slow. Poisoning, it is true, does occasionally follow a prescription of bismuth, but in such cases, when investigation has been made, the article dispensed has been pretty surely found contaminated with arsenic, a contamination dangerously common with the poorer grades of bismuth subnitrate. Locally, soluble bismuth compounds are astringent and irritant, and the insoluble ones soothing, healing, and antiseptic. But if applied abundantly to extensive wound surfaces, the insoluble compounds are capable of producing constitutional effects—acute stomatitis, catarrh of the intestines, and nephritis. Taken internally, bismuth compounds allay gastric pain or nausea, and tend to check diarrhœa.

2. The Compounds of Bismuth Used in Medicine.—The compounds of bismuth official in the United States Pharmacopœia are basic bismuth *nitrate* and *carbonate*, and a composite scale preparation containing the *citrate*.

Basic Bismuth Nitrate, $BiONO_3,H_2O$.—This salt, the *magistery of bismuth* formerly so-called, or *white bismuth*, is official as *Bismuthi Subnitras*, Bismuth Subnitrate. It is "a heavy, white powder, of somewhat varying chemical composition, odorless and almost tasteless, and permanent in the air. Almost insoluble in water, and insoluble in alcohol; but readily soluble in nitric or hydrochloric acid. When heated to 120° C. (248° F.), the salt loses water (between 3 and 5 per cent. of its weight); and when subsequently heated to redness, it evolves nitrous vapors, leaving from 79 to 82 per cent. of its weight of a yellow residue which is soluble in nitric or hydrochloric acid, and blackened by hydrogen sulphide. When brought upon moistened blue litmus paper, the salt shows a slightly acid reaction" (U. S. P.). This salt should not be prescribed with potassium iodide nor with the carbonates of the alkalies. Specimens of poor quality are apt to contain variable proportions of arsenic, even enough, it may be, to cause distinct poisoning in therapeutic doses. To detect this contamination, treat the specimen with sulphuric acid, evaporate to dryness, dissolve the residue in hot distilled water, and test the solution by Marsh's test for arsenic.

Bismuth subnitrate produces the effects of the insoluble bismuth compounds already described, and is the principal medicinal preparation of the metal. The only peculiarities of its action are the production of a garlicky odor to the breath of the taker, and a blackening of the stools. The salt is given internally in doses of wide range, from 0.30 gm. to 2.50 or even 4.00 gm. (from five grains to a drachm), taken as a powder or suspended in mucilage. Externally it is used as a dusting powder in excoriations and sores, or, suspended in water, ten-per-cent. admixture, in the so-called antiseptic treatment of wounds.

Basic Bismuth Carbonate $(BiO)_2CO_3,H_2O$.—This salt is official as *Bismuthi Subcarbonas*, Bismuth Subcarbonate. It is "a white, or pale yellowish-white powder, of somewhat varying chemical composition, odorless and tasteless, and permanent in the air. Insoluble in water or alcohol, but completely soluble in nitric or hydrochloric acid, with copious effervescence. When heated to redness, the salt loses water and carbon dioxide, and leaves from 87 to 91 per cent. of a yellow residue which is soluble in nitric or hydrochloric acid, and blackened by hydrogen sulphide" (U. S. P.).

Bismuth subcarbonate is substantially a duplicate of the subnitrate in all its properties, and may be used for the same purposes and in the same manner as the latter salt.

Bismuth Citrate, $BiC_6H_5O_7$.—This salt is official under title *Bismuthi Citras*, Bismuth Citrate, solely for the purpose of making the next-to-be-named compound. Bismuth citrate is made by boiling the subnitrate in a solution of citric acid. It is "a white amorphous or micro-crystalline powder, odorless and tasteless, and permanent in the air. Insoluble in water or alcohol, but soluble in ammonia water, and in solutions of the citrates of the alkalies" (U. S. P.). By dissolving this salt in water of ammonia, filtering, evaporating to a syrupy consistence, and spreading the syrupy fluid on glass plates to dry, a dry film breaking up into scales is obtained, analogous to the scale preparations of iron. These scales are official under the title *Bismuthi et Ammonii Citras*, Bismuth and Ammonium Citrate. They appear as "small, shining, pearly or translucent scales, odorless, having a slightly acidulous and metallic taste, and becoming opaque on exposure to the air. Very soluble in water, and but sparingly soluble in alcohol" (U. S. P.). The compound should be kept in small tightly stoppered bottles, and away from the light, for on exposure it loses ammonia, and then fails to dissolve wholly in water. The chemical composition, as in the case of the analogous preparations of iron, is obscure; some regard the scales as containing a true double citrate of the bases, and others consider them as a mere admixture.

This preparation is unique as being a soluble compound of bismuth. It is used internally for diarrhœa, and, in medicinal dose, proves astringent and mildly irritant. The dose ranges from 0.06 to 0.20 gm. (gr. i. to iij.).

Edward Curtis.

BISMUTH, POISONING BY.—The two most important compounds of bismuth are the subnitrate (basic nitrate, magistery of bismuth) and the subcarbonate. These preparations are extensively used, in doses of 0.65 to 3.9 gm. (gr. x. to lx.), or more, in the treatment of diarrhœa and other forms of intestinal irritation. The subnitrate of bismuth was considered an active poison by many of the earlier writers, who state that symptoms of gastro-enteritis frequently follow its administration in doses of 1.9 to 7.7 gm. (ʒ ss. to ij.) daily. A case is recorded in which 7.7 gm. of this substance, administered to an adult, caused severe symptoms of irritant poisoning, followed by death on the ninth day. At the post-mortem examination the tonsils, uvula, pharynx, and epiglottis were found gangrenous; the œsophagus and stomach were very red, and the whole intestinal canal was red, and here and there gangrenous, especially at the rectum (Christison).

As the subnitrate and subcarbonate of bismuth are used very freely without any bad results, it is doubtful if they can be considered irritants even in comparatively large doses. The best authorities of the present day generally agree in attributing the effects noticed by the earlier writers to impurities in the drug or to some other cause. The preparations of bismuth have frequently been found to contain arsenic in the form of arseniate of bismuth. Dr. Taylor found arsenic in three samples of subnitrate of bismuth out of five examined by him; Dr. Rogers, in eight samples out of ten. Herepath examined fourteen samples and found arsenic in all. Salisbury found arsenic in thirteen samples out of eighteen; he also examined five samples of the subcarbonate of bismuth and found arsenic in all.

There can be no doubt that the symptoms produced

by subnitrate of bismuth have been sometimes due to the arsenic which it contains, as in the following cases: A physician had occasion to place himself upon a treatment of subnitrate of bismuth. After a day or two he noticed a puffiness about the eyes and gastro-intestinal irritation. These symptoms disappeared when the use of the bismuth was discontinued, but reappeared upon the renewal of the medicine. The bismuth was found, upon analysis, to contain arsenic (Fullerton). Twenty-six grams (400 grains) of subnitrate of bismuth was administered to a child ten months old, over eleven consecutive days, for a moderately severe attack of inflammatory diarrhœa. After one week there was puffiness of the limbs and face; the child became severely ill, fretted, moaned, and was very restless; the diarrhœa became suddenly worse. The conjunctivæ were slightly injected, the tongue was dry, the pulse rapid, the skin hot and dry. There was no eczema. The urine was free from albumin. The symptoms disappeared when the medicine was discontinued. The bismuth was found, upon analysis, to contain 0.150 per cent. arsenic acid. Another sample was found to contain 0.240 per cent. arsenic acid (Underhill). This is the largest amount of arsenic which has been found in any of the preparations of bismuth, so far as the writer has been able to learn.

The presence of arsenic in these preparations is explained by the fact that the ores of bismuth, from which they are manufactured, contain arsenic. The processes employed for their manufacture are intended to remove all but the slightest trace of arsenic. Up to a comparatively recent date this result was frequently not attained. At the present time, however, greater care is taken in their preparation, and it is only rarely that either the subnitrate or the subcarbonate of bismuth is found to contain more than the merest trace of arsenic.

It has been stated that subcarbonate and subnitrate of bismuth containing 0.129 per cent. arsenic did not produce symptoms of poisoning when administered to dogs in doses of 15 to 30 gm. (Parral and Garnier). It is possible, therefore, that the bad effects which have been caused by these preparations are to be attributed, in some cases at least, to other causes. Idiosyncrasy has been suggested. Monneret thinks they may be due, in certain cases, to an exacerbation of the trouble for which the bismuth was administered. It has been suggested that an excess of free acid in the stomach, or acid salts, administered simultaneously with the subnitrate, may, in some cases, have converted the latter into a soluble poisonous salt of bismuth. Sobernheim explains the poisonous effects in the fatal case related by Christison, by supposing that the bitartrate of potassium, which was administered with the subnitrate of bismuth, converted the latter into an acid nitrate, which is shown by experiments on animals to be an irritant poison. Herbelin has found considerable free nitric acid in subnitrate of bismuth. The presence of this acid, or of the normal or acid nitrate, in specimens which have been carelessly prepared, may also explain some of the symptoms which have been observed. Lead has been detected in subnitrate of bismuth (Carnot, Chapins, Linossier), but the amount was small, and it does not appear that the symptoms which have been observed in any case can be attributed to it. It is noticeable that, with improved methods of manufacture and greater care in carrying them out, cases of poisoning by these preparations have become exceedingly rare, if, indeed, they occur at all. No cases have been reported during the past few years. This fact tends to confirm the belief that the cases which have been reported were due to some of the causes which have been mentioned, rather than to any direct poisonous action of the preparations themselves.

Preparations of bismuth are frequently administered in the treatment of gastro-enteritis caused by the metallic irritants. The discovery of arsenic in the subnitrate of bismuth thus administered has been sufficient to invalidate the results of the chemical analysis in certain cases of alleged poisoning by arsenic, in which the amount of arsenic detected in the organs was small (Rogers, Reese). The attempt to account for the presence of arsenic in the body by suggesting that it may have come from the bismuth administered, is frequently made. It is important, therefore, whenever these preparations are given in cases of suspected poisoning, to preserve a sample for subsequent analysis, if necessary.

The subcarbonate of bismuth, if pure, is undoubtedly as free from irritant properties as is the subnitrate. It is, however, more soluble than the subnitrate, and is, therefore, more liable to become converted into a soluble salt of bismuth by the acids of the gastric juice, or by acid salts if these are administered simultaneously with it. As the soluble salts of bismuth are poisonous, the subnitrate would appear to be the safer preparation when large doses are to be administered, or when the administration is to be continued for a long time.

Under the name "pearl white" the subnitrate of bismuth is used to a considerable extent as a cosmetic. The subcarbonate and oxychloride of bismuth are sometimes used for the same purpose. There is no evidence to show that they are absorbed through the skin, or that they produce, if pure, any injurious consequences, aside from stopping up the pores and thus interfering with the healthy action of the skin. Bismuth preparations containing arsenic or lead might, however, produce injurious effects when used as cosmetics.

Experiments on animals show that the soluble salts of bismuth are poisonous. The action of the following salts has been investigated: the nitrate (Orfila), the citrate of bismuth and ammonia (Stefanowitch, Lebedoff, Feder-Meyer, Mory), the acetate (Bricka), and the tartrate of bismuth and potassium (Rabuteau). The symptoms which follow the administration of these salts do not differ materially from those produced by the metallic irritants generally. The most constant post-mortem appearances are inflammation of the stomach and intestines, and a more or less extensive fatty degeneration of the liver, kidneys, and heart. Lebedoff states that the glycogen disappears from the liver after the long-continued administration of the citrate of bismuth and ammonia. The red blood corpuscles in animals poisoned by this compound present a finely granular appearance, and masses of small free granules may be seen in the serum. These appearances point to the destruction of the blood corpuscles (Feder-Meyer).

Absorption and Elimination.—When subnitrate of bismuth is administered, the greater part is separated with the fæces, either unchanged or in the form of sulphide. A part is absorbed. Orfila detected bismuth in the liver, spleen, and urine of dogs to which the subnitrate had been administered. Bergeret and Mayençon state that, when the subnitrate is administered, bismuth can always be detected in the urine after a few hours. They also detected it in the serous exudation of dropsy. When a few grains are given to rabbits, it can be found, in from twenty to thirty minutes, in the urine, spleen, blood, and muscles, and even eight days after the administration it can be detected in all the tissues. The last-named authorities detected traces in the liver and kidneys of a man who had taken 1 gm. of the subnitrate five days before death, but they failed to find it in the body of a woman who died sixty-two days after the ingestion of 3 gm. (quoted by H. C. Wood, Jr.).

After the administration of the soluble salts of bismuth, the metal has been detected in the urine, fæces, saliva, stomach, liver, spleen, and bones. It can be detected in the liver many months after the last administration (Bricka). It is eliminated with the urine, fæces, and, according to Dubinski, with the saliva.

William B. Hills.

BISTORT.—The rhizome of *Polygonum Bistorta* L. (fam. *Polygonaceæ*).

The rhizome is covered with roots. It is as large as the little finger, from 5 to 15 cm. long (2 to 6 inches), somewhat flattened, transversely wrinkled, variously, often excessively, once or twice doubled upon itself like the letter S. When dry it is hard and brittle, dark brown

externally, reddish brown within, with a single circle of well-marked woody bundles; taste, astringent; odor, slight.

CHEMICAL COMPOSITION.—Galli-tannic (twenty-one per cent.) and gallic acids, starch, and less important substances.

USE.—Bistort has been a well-known and considerably used astringent. The large proportion of tannic matters entitle it to rank high in this rather numerous class of medicines. Of course it is vastly exceeded in this respect by the various galls, and has no advantage over the tannic acid so easily prepared from them. It is, therefore, now but little used. It has also been employed as a source of starch.

Dose, 1 or 2 gm. (gr. xv. ad xxx.).

W. P. Bolles.

BITTERSWEET.—DULCAMARA. "The young branches of *Solanum Dulcamara* L. (fam. *Solanaceæ*)" (U. S. P.). This is a weak, straggling, half-woody, hairy perennial, its stems often six or eight feet long and reclining upon shrubbery. It has alternate leaves, many of them pinnately three to five lobed or parted, pretty blue star-

FIG. 482.—Bittersweet. Plant reduced and flower enlarged. (Baillon.)

shaped flowers, in small cymes, and bright scarlet, shining, oval fruits, about half as large as cranberries, and somewhat poisonous. It is a native of Europe and Asia, and thoroughly naturalized in this country, where it is abundant along streams and ditches and in wet pastures. The Pharmacopœia describes the drug as follows: "About 5 mm. or less, thick, cylindrical, somewhat angular, longitudinally striate, more or less warty, usually hollow in the centre, cut into short sections. The thin bark is externally pale greenish or light greenish brown, marked with alternate leaf scars, and internally green, the greenish or yellowish wood forming one or two concentric rings. Odor slight, taste bitter, afterward sweet."

Composition.—In spite of a great deal of study, our knowledge of the composition of dulcamara is very uncertain. Its bitter and sweet taste are due to two glucosides, *dulcamarin*, similar to saponin, and *picroglycion*, besides which there exists a body called *solanin* or *solanine*. The latter is the most indefinite of all the constituents. It is said to decompose after the manner of a glucoside, with which it is classed by Merck, yet it contains nitrogen and yields salts, like the alkaloids. It is not even known if it be identical with the solanine of other species of the genus. For a full account of solanin see article on Potato, under *Poisonous Plants*. Wax, gum, starch, and resin are also present.

Solanin exists in such very small amount as to contribute little activity to the drug, which has been used in the most indefinite way as an alterative and tonic.

Its close relation to a number of deleterious solanin-bearing plants has made its reputation suspicious, but the records of injury, from the green plant even, are very few; from the dried, almost none. A large quantity of a decoction made from a peck of the stems has been taken, followed only by transient numbness, dryness of the mouth, and paralysis of the tongue. In medicinal doses it can scarcely be said to have any physiological action. The amount of solanin, especially in old stalks, is very small. Given in copious hot decoction, bittersweet is probably diaphoretic and diuretic, and is still occasionally used in chronic rheumatism, as well as in psoriasis and some other chronic skin diseases. Dose, 4 to 8 gm. (ʒ i. ad ʒ iv.). A fluid extract is made (*Extractum Dulcamaræ Fluidum*, U. S. P.), but an extemporaneous decoction is probably a better form.

H. H. Rusby.

BITTERSWEET, FALSE OR CLIMBING, should not be confounded with the above, though its composition is in part similar. It is the bark of *Celastrus scandens* L. (fam. *Celastraceæ*), a very woody twiner, very common in many parts of the United States. This is the "bittersweet" whose orange-colored fruits, after bursting open in the fall to display the handsome scarlet-arilled seeds, is largely used for decorative purposes. Its composition and properties are even less known than those of the last. Its active constituent is apparently a saponin-like glucoside, and it has been used in syphilis and hepatic disorders.

H. H. Rusby.

BLACK BARREN MINERAL SPRING.—Lancaster County.

POST-OFFICE.—Pleasant Grove. Hotel.

ACCESS.—Viâ Pennsylvania Railroad to Columbia, on the Susquehanna River; thence viâ Columbia and Port Deposit Railroad to Haines' Station; thence by private conveyance two and one-half miles to springs.

The location is in the southern portion of Lancaster County, one mile from the Susquehanna River and about three miles from where it crosses the Maryland line. The springs have an elevation of about six hundred feet above the sea level, and are surrounded by a picturesque, undulating farming country, containing varied and pleasing landscapes. About a mile to the south is an extensive serpentine ridge known as the "Black Barren," from which the spring receives its name and doubtless its source. An analysis of the water by Messrs. B. H. Rand and Charles Cresson, of Philadelphia, resulted as follows:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Grains.
Sodium sulphate	1.20
Magnesium sulphate	3.24
Silica and suspended matter	1.30
Total	5.74

The water appears to be a light-sulphated saline. A re-examination is desirable, as this analysis is evidently incomplete. The water is bottled and sold, and the spring is also used as a resort from May to October. The water is recommended in renal and hepatic disorders, dyspepsia, and rheumatism.

James K. Crook.

BLACK DEATH. See *Bubo Plague*.

BLACKBERRY.—RUBUS. "The bark of the root of *Rubus villosus* Ait., *R. Canadensis* L., and *R. trivialis* Mx. (fam. *Rosaceæ*)" (U. S. P.). The first mentioned of these species is the common high-bush blackberry of the Northeastern United States, the second is our running blackberry or dewberry, the last is the common sand blackberry of our Southeastern coast region, and this contributes the most of the drug. Experiments with the collecting of the second-named species lead the writer to doubt greatly that it can be collected on a commercial scale. The operation is excessively tedious, and the amount collected in a day extremely small. Both the others are collected with great ease.

The commercial bark is of a rather dark gray brown color, and occurs in slender, rather tough, tightly curved quills, rarely so thick as a lead pencil, with more or less adhering rootlets. Occasionally the wood is contained in them, but they are commonly so tightly closed and cord-like that they appear solid, as though containing the wood, when in reality they do not. The bark is decidedly thick for so small a quill. The drug has little odor, and a very astringent, slightly bitter taste.

Rubus contains about twelve per cent. of tannin and nearly one per cent. of the bitter glucoside villosin, which is soluble in alcohol and slightly so in water. Its properties are merely astringent, due to its tannin. The dose is 2 to 8 gm. (ʒ ss to ij.), and the fluid extract is official. The leaves of blackberry, raspberry, and strawberry are similarly used. They combine considerable gum with their tannin. *H. H. Rusby.*

BLADDER. (ANATOMICAL.)—The urinary bladder presents a body, a neck, an apex, and a base, or bas-fond. It is sometimes absent as a distinct organ, owing to an arrest in the development of the parts, when it forms but one cavity with the rectum. It is never double.

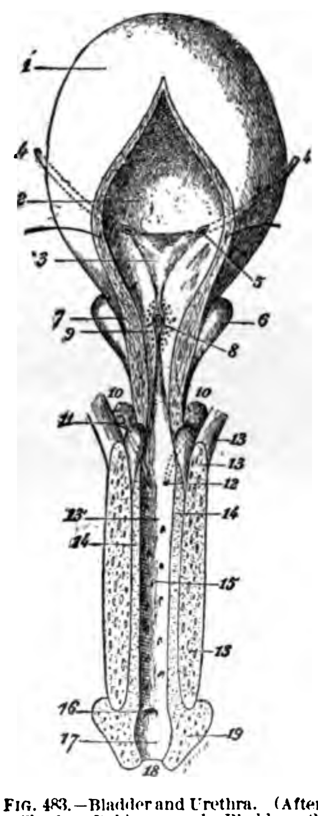

FIG. 483.—Bladder and Urethra. (After Charles Debierre.) 1, Bladder; 2, fundus of the organ; 3, triangle of Lieutaud; 4, 4, ureters; 5, vesical orifice of one ureter; 6, prostate; 7, section of the anterior portion of the neck of the bladder; 8, verumontanum, pierced by the orifice of the prostatic utricle and by the ejaculatory canals; 9, orifices of the prostatic glandules; 10, membranous portion of the urethra; 11, Cowper's glands; 12, opening of outlet from these glands; 13, 13, corpora cavernosa of the penis; 13′, spongy portion of the urethral canal; 14, 14, corpora spongiosa; 15, sinus of Morgagni; 16, valve of Guérin; 17, fossa navicularis; 18, meatus; 19, glans penis.

It may, however, extend in a constricted form up to the umbilicus in those cases of arrest of development in which the urachus fails to undergo obliteration.

In a general way it may be said that when distended to its full capacity, the bladder is about twice as large as the fist of the subject. In this description the organ will be supposed to be distended to its usual capacity.

It occupies the front part of the pelvic cavity and the lower part of the hypogastrium.

The direction of its axis, that is, of the line extending from the apex to the centre of the base, is about the same as that of the upper strait of the pelvis, and therefore the same as that of the body and neck of the female uterus. The direction of the neck is forward, parallel to the line of the axis of the lower strait of the pelvis. The line from the apex to the orifice of the neck would be represented by a curved line corresponding to the curved axis of the cavity of the pelvis.

The bladder is held in its position by the connection of its neck with the pelvis through the short glistening fibres of fibrous tissue called the ligament of the bladder; also by the connection of the apex with the urachus and the umbilicus opening. The reflection of the peritoneum from the abdominal wall to the rectum, along its posterior surface and over the upper part of the lateral surfaces, assists in keeping the organ in position. The bladder is also supported by the rectum upon which the base rests. Thus fixed, it may expand and contract more or less, but it possesses no movement in its entirety.

The shape of the organ is more or less conical, with the base situated below. The anterior surface is in relation below with the posterior surface of the pubis, and,

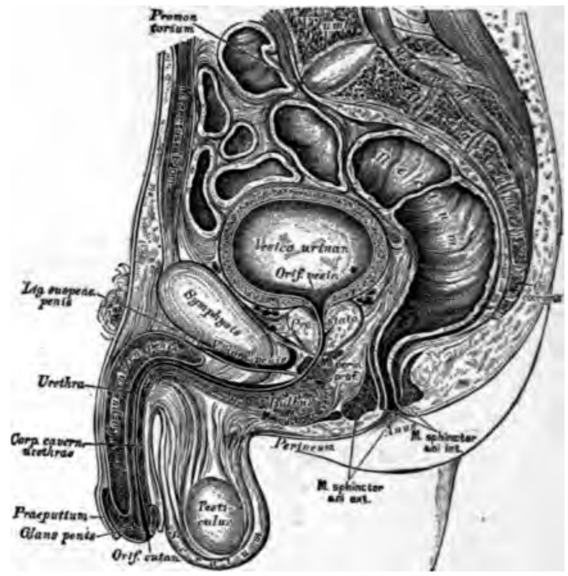

FIG. 484.—Sagittal Median Section through the Male Pelvis. About one-third natural size. (After Heitzmann.)

above the pelvis, with the abdominal walls, *i.e.*, with the posterior surface of the rectus abdominis muscles. It is almost always free, in this locality, from peritoneal covering. There is a thin layer of fat between the walls of the bladder. The posterior surface is in relation with the peritoneum, with coils of the ileum, and with the rectum. The peritoneum forms there the recto-vesical cul-de-sac.

The lateral folds of this recto-vesical cul-de-sac are called by some the posterior ligaments of the bladder. They enclose the obliterated hypogastric arteries and the ureters. The lateral surfaces are covered by peritoneum in the upper and posterior half and are there in relation with the coils of the ileum. But the lower and anterior half of these surfaces is free from peritoneum and is in relation with the pelvic areolar tissue. The obliterated hypogastric arteries cross, obliquely downward, the lateral surface; the peritoneum does not extend in front of this cord. The spermatic duct curves backward along the posterior portion of the lateral surface, passing on the inner side of the ureter.

The apex gives attachment to the urachus. It is covered with peritoneum.

The base is in relation, on the middle line and in front, with the prostate and behind with the rectum. On the side it is in relation with the spermatic duct, seminal vesicles, and the ureters.

The bladder is of a white flesh color. It is a resistant organ; it is contractile. It presents first a peritoneal coat which invests only its apex, its posterior surface, and the upper part of the lateral surfaces. The anterior surface, the lower part of the lateral surfaces, the base, and the neck are entirely free from peritoneum.

The second coat is a muscular coat composed of three layers or sets of fibres. The superficial fibres are formed of longitudinal fibres and are composed of three groups. The upper group comes from the urachus and spreads

over the apex of the bladder. The anterior group comes from the pubis, to which they are attached by glistening aponeurotic fibres called the ligaments of the bladder; they spread over the anterior surface. The posterior group comes from the base of the prostate and expands over the posterior surface of the organ. The middle muscular fibres are more or less circular. They are in greater number around the neck, where they form the sphincter of the bladder or vesical sphincter. They form a sort of elliptical sphincter around the orifices of each ureter. The last and innermost layer of fibres are the plexiform fibres, which have no definite direction. These fibres are not uniformly distributed over the organ, but form bundles more or less prominent which cross one another in all directions. Some of the bundles make quite a projection on the inner surface of the bladder, and may give rise to small pouches or alveoles. The muscular fibres are all of the smooth variety.

The submucous areolar layer is marked, but presents nothing special.

The mucous layer presents nothing of interest except at the base. There the organ presents posteriorly a slight depression called the bas-fond. In front is seen a triangular surface called the trigone; it corresponds to the prostate. The front angle corresponds to the urethra, and the two posterior angles to the openings of the ureters, remarkable for their slit-like shape. The surface of the trigone is smooth, and there the submucous layer is scanty and the mucous membrane is adherent to the subjacent muscular tissue.

The mucous membrane is continuous in front with that of the urethra, and behind with that of the ureters.

The exact nature of the glands which secrete the mucus of the bladder is not well settled as yet, but they are more like single racemose glands than anything else.

The bladder is provided with three arteries on each side, the upper, middle, and inferior. They are derived from the internal iliac.

The veins are specially abundant around the neck of the organ, where they form a marked plexus, the main formative branch of which is the dorsal vein of the penis.

The lymphâtics open into the pelvic glands.

The nerves of the body of the bladder come from the sympathetic. Those of the base and neck come from the third and fourth sacral nerves.

The bladder is developed from the cloaca, *i.e.*, the cavity formed by the terminal point of the primary intestinal cord and the pedicle of the allantois. In course of development there is thrown out a transverse partition which separates it from the rectum, and the pedicle of the allantois becomes obliterated and is then known as the urachus.

PECULIARITIES OF THE BLADDER.—The bladder is the largest of all cavity organs and of all the receptacles that are found in the course of the excretory apparatuses of the organs of the body. It corresponds to the gall bladder and to the seminal vesicles. Together with the stomach it is the only organ that is susceptible of considerable enlargement within the bounds of health.

It encroaches upon two large cavities, the pelvis and abdomen. When empty it is flat against the pelvis. The difference of direction of the various axes is worthy of notice. The organ is as it were suspended by its two extremities, the neck and the urachus; but the neck is the most immovable. The urachus recalls the pyramidal process of the thyroid body. Upon close examination the bladder will be found to be really fusiform, the two pointed extremities corresponding to the apex or urachus and to the neck.

The absence of peritoneum on the anterior surface when the bladder is distended is the reason why that surface is the spot chosen when it is desired to penetrate into the bladder. The relation of the base with the rectum makes the exploration by way of the rectum indispensable in many bladder troubles. The presence of the urachus is noteworthy. The mode of attachment and the fixed character of the neck are evidently intended to direct the action of the fibres toward the orifice of the urethra.

The presence of three muscular coats is noticeable; so also is the triple origin of the longitudinal fibres, recalling the similar arrangement of the longitudinal fibres of the stomach. The sphincters formed by the outer fibres around the neck and around the orifices of the ureters are to be noticed. The bundle arrangement of the plexiform fibres is unique. The formation of alveoles on the mucous surface by the projection of these fibres is an arrangement worthy of notice.

The presence of the bas-fond, of the trigone, and of the slit-like orifices of the ureters is peculiar, and so also is the indistinct character of the glands of the mucous membrane. That a small organ like this should be provided with six arteries is remarkable. It is true that the organ is hollow and that the arteries are small. The presence of an abundant venous plexus around the neck of the bladder is to be noted. That the body and the neck possess each a different nerve supply is also striking.

The development of the bladder in common with the rectum is to be remembered; and so also is its common development with the allantois. Arrest of development by which the partitioning of the bladder from the rectum does not take place accounts for those cases in which a cloaca persists into adult life. Failure of obliteration of the pedicle of the allantois explains the persistence of umbilical fistula. The fact that the bladder is developed separately from the urethra accounts for the cases of unperforated urethra in which the development is arrested before the proper time. The arrest of development before the abdominal wall is closed accounts for the cases of exstrophy of the bladder. In fetal life the bladder is distinctly fusiform in shape.

Owing to the smallness of the pelvic cavity in the child the bladder encroaches at that age more on the abdominal cavity.

In old people the muscular fibres become more fibrous and the glands secrete more mucus.

The bladder of the female is said to be larger than that of the male. The transverse diameter is also more apt to be greater than usual in the female sex. The posterior surface is in relation with the uterus, and the base with the vagina. The reflection of the peritoneum from the bladder upon the uterus is called Douglas' cul-de-sac. It extends down to the upper part of the posterior wall of the vagina.

Edmond Souchon.

BLADDER AND URETHRA OF THE FEMALE, DISEASES AND INJURIES OF.—The mode of origin of the female bladder and urethra makes them liable to developmental defects; their situation in the pelvis and their relation to neighboring organs may influence their size, shape, and mobility, and may render them specially subject to trauma and to the introduction of foreign bodies and infectious micro-organisms. Their connection with the kidneys and ureters subjects them to the ever-changing character of the excretion from those organs. Finally, the nature of their anatomical structures is such as to afford a favorable starting point for benign and malignant neoplasms, with or without inflammatory conditions. Either a single one or several of the above factors may be of clinical importance in so far as they possess the power to modify the function of the bladder as a reservoir, to qualify its power to expel its contents, and to interfere with the urethra as a *conduit.*

DEVELOPMENTAL DEFECTS OF THE BLADDER AND URETHRA.

For information in regard to the nature and mode of origin of these the reader is referred to the article on *Teratology* in a later volume.

ACQUIRED DEFORMITIES OF THE FEMALE BLADDER AND URETHRA.

The anatomical relations of the urethra and bladder to the pelvic and abdominal viscera subject them to numerous changes in calibre, contour, and position, and more or less seriously affect their functional activity.

Dilatation of the Urethra.—The lumen of the normal female urethra differs greatly in diameter, varying with age and social condition, whether single or married, nullipara or multipara. An imperforate hymen, vaginal atresia, or absence of the vagina may lead to coitus per urethram, and thus ultimately result in the greatest possible dilatation of the whole canal. In some this condition brings about complete inability to retain urine; in others the disability is only partial, manifesting itself during coughing, sneezing, straining, or lifting; in a few cases, finally, the control remains perfect. The condition is easily recognized by the readiness with which the finger can be introduced into the bladder.

Forcible Dilatation.—Kelly emphasizes the fact that "with the cases of dilatation of the urethra where a large finger has been bored in for diagnostic purposes . . . the extensive rupture of the muscular fibres is then followed by an incontinence which is often permanent. These cases are fortunately becoming rare, as this *barbarous* way of examining the bladder is being given up. With our present facilities for examination, we are never warranted in introducing the finger through a urethra which is not already dilated so as to admit it without resistance." The vestibular end may be distended by a cyst, by the presence of pus in Skene's ducts, by a chancre or chancroids or by other growths, or by the presence of foreign bodies within the meatus.

Dilatation of the middle portion of the urethra (urethrocele) is the commonest form. "The anterior (superior) wall of the urethra maintains its normal position, but the central portion of the canal being distended settles down so that in time the urethra, in place of being a straight or slightly curved canal, becomes (nearly) triangular; a cavity is thus formed in the central portion of the urethra." Within this pocket urine may collect and undergo chemical changes; stones are liable to form or lodge therein on their way through the urethra; and new growths may be arrested or may develop there, inciting a urethritis and causing obstruction to the outflow of urine. Dilatation of the middle third is most likely to be confounded with thickening of the urethro-vaginal septum or with a suburethral abscess. A curved sound passed along the floor of the urethra will enter the pocket, and its point can then be readily felt through the anterior vaginal wall which will be of normal thickness. Pressure upon an abscess will force pus into the urethra.

Excision of the redundant portion of the middle third can best be accomplished after the method of Frank, who places a small catheter in the urethra, excises a wedge-shaped piece from the urethro-vaginal septum, including its whole thickness, and extending from the external urethral orifice to within about 1 cm. of the internal orifice, and continuing the incision as an ellipse along the vaginal wall beyond the neck of the bladder. The whole wound is then to be closed by transverse sutures.

"By flattening the outer end of the urethra and at the same time bending it, Pawlik (*Wien. klin. Woch.*, 1883, Nos. 25 and 26) relieved several patients of incontinence. His plan is to draw the orifice of the urethra well forward toward the clitoris and sharply to one side; then, marking the point on the side to which it could be drawn without excessive traction, a narrow denudation about 2 cm. (three-fourth inch) long is made in the sulcus and sutures passed to hold the urethra in that position. After a week, when the sutures are removed, the other side of the urethra is drawn upward and outward in the same manner, and the sulcus on that side denuded and sutured. By this means the urethra receives a sharp bend forward and the posterior wall is strongly flattened against the anterior by traction on both sides" (Kelly).

Gersuny (*Centralbl. f. Chir.*, 1889, p. 433) dissected out the whole urethral canal as far as the neck of the bladder, twisted the urethra one and a quarter times on itself, formed a series of spiral folds, and then sutured the canal in this position.

Dislocation of the Urethra.—The protected position of the urethra under the pubic arch, and its dense fibrous attachments, tend to prevent injury; yet in spite of these conditions dislocation is one of the affections frequently met with in women with relaxed pelvic floors, lacerated perineum and uterine displacement, conditions which are often associated with rectocele and vesicocele. Under these conditions an examination reveals the fact that the whole urethra has been displaced outward and forward, having rotated around the symphysis, assuming nearly a U shape. In other cases the upper portion of the canal with the base of the bladder descends, the lower section remains *in situ*, converts the urethra into an S-shaped tube, and renders the introduction of a catheter somewhat difficult. When associated with complete prolapse of an hypertrophied cervix uteri the whole urethra lies outside the vulva. The presence of large subperitoneal or intraligamentous tumors, or the existence of a full bladder during pregnancy or labor, may draw the bladder and urethra, changing the long axis of the latter from the horizontal to the vertical, and often rendering it very difficult to introduce a catheter, which under these circumstances should always be of soft rubber.

As a prophylactic measure, during labor, whether normal or instrumental, the bulging mass (anterior cervical lip, urethra, or both) between the symphysis and the descending head, should be pushed upward behind the symphysis so as to permit the occiput to descend under the pubic arch.

The SYMPTOMS of dilatation and dislocation of the urethra are similar to those of other urethral diseases. Dilatation of the whole canal is characterized by complete or partial incontinence, loss of control on lifting, coughing, sneezing, etc. Dilatation of the lower portion does not interfere with function, and is manifested only by the symptoms of the accompanying urethritis. Dilatation of the middle portion, like dislocation of the urethra, adds to the symptoms of urethritis the need of making an increased effort, as in overcoming an obstruction, much less marked when lying down than when urinating in the erect position.

The DIAGNOSIS is made by the use of the curved sound for the purpose of determining the exact curve of the urethra; by the introduction of the bulbous sounds or the urethrometer to ascertain any variations in the calibre and the portion involved; and the use of the urethroscope to locate the seat of the urethritis, and at the same time to facilitate the application of appropriate remedies. The finger introduced into the vagina will appreciate any thickening, the presence of a new growth or foreign body, and the point of greatest tenderness.

The TREATMENT of dilatation following labor, the recent extraction of stone, the introduction of an instrument or finger, consists in waiting for a time in the hope that the urethra will contract, the patient being kept quiet in the mean time, and vaginal douches being administered from time to time. Urethral dilatation and dislocations other than the acute varieties do not tend to spontaneous recovery, but, from repeated sexual contact and succeeding labors, increase in size and importance. In chronic conditions the first duty is to remove the cause; next, to relieve the urethral inflammation; and, last and most important, to overcome the incontinence. With an intact or firm pelvic floor the urethra can be lifted up and, to a certain extent, compressed by a well-fitting, hollow-round, funnel-shaped ball, or by an Albert Smith pessary.

Prolapse or Eversion of the Urethral Mucosa.—As a rare accompaniment of a dilatation of the external urethral meatus, the mucous membrane of its lower third becomes detached from its submucous connections and gradually protrudes through that opening as a pale, deep red, or purplish tumor. As it increases in size it becomes very sensitive, and œdema, ulceration, and sloughing sometimes intervene. On the other hand, the prolapse may be limited to one side and may, in that location, resemble a caruncle. Eversion is an affection incident to any age, but is far commoner in young strumous children. Its etiology is not definitely known; it may follow a blow, straining, coughing, or rape.

TREATMENT.—In a recent case, cocainize the everted

membrane, and by taxis reduce it within the canal; keep the patient in bed, and give morphine enough to prevent spasmodic contraction during urination.

If reduction cannot be maintained or proves impossible, cut off the protruding membrane circumferentially, and unite the edges with fine catgut sutures. "Catch the edges as they are cut to prevent inversion and excessive hemorrhage."

Contraction of the urethra in any portion of its length is considered by Skene and others to be of much more importance and of more frequent occurrence than is usually accorded. Van de Warker (*Medical News*, July 16, 1887) says truly that "the lumen of the normal female urethra is not the same throughout its length. It is contracted toward the meatus, expanded in the middle portion, and narrows again as it approaches the bladder. The use of the urethrometer proves this. One must not, therefore, allow error to occur from the introduction of too large a bulb, which would move with more freedom at one point than at another." Van de Warker believes that *urethral strictures* are both as frequent and as important in the female as in the male, and he urges the importance of an examination with bulbous sounds in various urinary difficulties in the female. Sometimes the constrictions are arranged in series, and bulbs varying from No. 24 to No 27 will slip along in a series of jerks that offer but the slightest resistance to the surgeon's hand. More commonly, however, one or two of these bands are found located at the upper portion of the urethra. The sensation of meeting one of these bands is so characteristic and unmistakable that there is little danger of error.

Herman, quoted by J. W. White, reported the results of his examination of fifty-five female urethræ, in which cases no urinary trouble was complained of. In the majority a No. 17 catheter would pass, and in all but two a No. 14. He tabulated six of his own cases of stricture and collected twenty-three others, and found that etiologically child-bearing, the cicatrization of chancres (and chancroids), sometimes the so-called lupus of the vulva, and, in the young and middle aged, gonorrhœa are the chief factors. In the old women there was found stricture due to general fibrous thickening and induration of the urethra, occurring without any history of gonorrhœa or other discoverable local disease.

Contraction of the *meatus externus* (the form which is most frequently observed) is either produced by the too liberal use of caustics, in the attempted removal of new growths, or it results from severe vulvitis.

Treatment of Urethral Stricture.—"In women it is not safe to regard every case of urine retention as hysterical until, after a urethral examination by the bulbs, the passage is shown to be free from strictures, large or small" (Van de Warker). For the purpose of dilatation he makes use of the graduated steel sounds, the same as are used in treating male strictures. "The action is twofold—to dilate and to cause gradual absorption of the constricting exudate. In strictures of large size, forcible dilatation or divulsion may be used. The treatment, made two or three times a week, extends over a considerable length of time (from two to three months), but the relief given to the patient by the use of sounds is very satisfactory. As the dilatation of the urethra which they produce is no more important than the absorption caused by their use, the latter implies a more or less prolonged treatment" (Van de Warker). He believes that any one can verify this position upon the living subject by the habitual examination of the urethra with the exploratory bulbs in every case of pelvic disease that presents itself for treatment.

Herman found that rapid dilatation was so successful that he preferred it to any other method.

Dislocations of the Bladder.

Certain changes in the position, size, and relation of the pelvic and abdominal contents bring about, in the bladder, certain changes which distort that organ and interfere with the performance of its functions. The bladder being hemmed in by the symphysis in front, by the uterus and broad ligaments behind, and by the small intestines above, it is not surprising that its transverse diameter is increased at the expense of the antero-posterior diameter. In extreme distention the bladder rises vertically into the abdomen, even as high as the umbilicus; the urethra being at the same time put on the stretch. The bladder may be carried upward by ovarian tumors, fibroid growths, pelvic neoplasms, intestinal adhesions, the anteverted uterus of Alexander's operation, and the pregnant uterus. The laterally displaced bladder may form a part of the contents of the sac in inguinal or femoral hernia, and it has been found pouching into the foramen ovale. Inflammatory masses or large growths on one side force the bladder in the opposite direction, and thus lead to mistakes in diagnosis. These, however, can easily be avoided if the examiner himself passes the catheter in every case in which he is called upon to determine the nature of an abdominal enlargement. Adhesions between the fundus of the bladder and a uterus which is thrown backward will drag the bladder backward. Acute retroversion of the uterus, on the other hand, throws the cervix against the urethra, causes obstruction, and makes urination impossible. Of all changes in the position of the bladder, downward dislocation is the most common and important, often taxing to the utmost the surgeon's resources. The chief etiological factors are those which bring about prolapse of other pelvic viscera, viz.: the general lack of muscular tone common to most of our women, with relaxation of the pelvic floor, destruction of the perineum, malpositions of the uterus, etc.—in fact, all of the pathological conditions which involve those structures included by Hart and Barbour in the "displaceable portion" of the pelvis.

As exciting causes, we have the expulsive efforts of child-bearing, defecation, lifting, and violent jarring.

Downward pouching of the floor of the bladder, *cystocele*, while most frequently met with in multiparæ, is at times found in both young and old nulliparæ.

Cystocele presents itself as a soft, round, elastic body projecting into and distorting the vagina. It is easily replaced, but soon returns, and it is enlarged on coughing, straining, or lifting. In severer grades the bladder can be forced through the introitus, by which it may be constricted, giving to it an hour-glass shape. In an extreme case of cystocele, the vaginal wall with the bladder, uterus, and rectum is extruded through the vulva. Its surface then becomes cracked, eroded, ulcerated, and very sensitive; the ureters are dragged down and bent at an acute angle; the outflow of urine is impeded, and dilatation of the ureters and renal pelvis with hydronephrosis intervenes.

Extroversion of the bladder through a dilated urethra, with involvement of the whole thickness of the bladder wall, is a most unusual form of dislocation. It presents the appearance of a deep red or purplish tumor emerging from the meatus, and very sensitive to touch and on contact with the clothing. Careful examination may determine the ureteral orifices within the furrowed mass. The inception of the difficulty may be due to torsion of a pedunculate growth which arises from the trigone and makes its way through the relaxed meatus internus and urethral canal. Under repeated straining efforts, more and more of the bladder is slowly dragged along the canal until it protrudes from the meatus externus. Infants and young children are the most frequent victims, while those past middle life rarely suffer from this form of dislocation.

The symptoms, as described by Skene, are as follows: "The patients, even before the tumor appears, feel strong pressure in the organ on urination, and may have stoppages in the stream, and retention. After a time these symptoms become aggravated, a small red tumor appears at the meatus, and with each urination enlarges. In some cases, when the desire to urinate is felt, severe contraction of the bladder takes place, but no urine flows. Then suddenly the little tumor disappears inside, and the urine flows freely. With each appearance of the tumor there is considerable constitutional disturbance, and after a

time the appetite is lost, and the sufferer emaciates rapidly. From continual traction on the ureters they may become inflamed, as also the kidneys, and uræmia supervenes. Blood is sometimes passed with the urine. Cystitis may occur, which increases the suffering and danger. The mucous membrane may become hypertrophied, congested, and even œdematous. The constitutional symptoms bear no relation to the amount of tissue extruded or the area of mucous surface exposed."

The DIAGNOSIS depends upon the passage of a sound into the bladder, which will be found abnormally short. At the same time it will be found that the pedicle of the tumor-like mass is made up of the base of the bladder. The ureters, if located upon the mass, will confirm the true condition.

The TREATMENT of bladder dislocations calls for the removal of the cause, be it the separation of adhesions, the removal of abdominal or pelvic tumors, the repair of the pelvic floor, or the replacement and maintenance, in its normal position, of a prolapsed uterus.

The extroverted bladder must be replaced. Anæsthetize the patient, place her in the knee-breast (Kelly) position, and with gentle compression and manipulation invert the prolapsed organ. Place the patient in bed, by preference lying upon the abdomen or in the lateral position. Pack the vagina with sterile gauze from day to day while the patient is in bed, and insert a hollow-round or other pessary when it is deemed prudent to permit the patient to assume the upright posture. If the bladder prolapses, narrow the urethral canal as in the treatment of dilatation.

Hypertrophy and Atrophy of the Bladder.

Hypertrophy of the bladder involves chiefly the muscular structure and is due to the presence of an unnatural stimulus to contraction, such as the presence of foreign bodies, neoplasms, calculus, or any means by which the organ is impelled to excessive contractile effort. When the bladder wall is thickened and at the same time the organ has become dilated, the condition is designated *eccentric hypertrophy*; if thickened and contracted, *concentric hypertrophy*. The latter is usually met with in tuberculous cystitis.

Thickening of the bladder wall is easily recognized by introducing a sound into the bladder and estimating the thickness by the hand placed upon the abdominal wall, or by the finger introduced through the vagina.

On removal of the obstruction, and after the cystitis has been cured or the irritating factor has been removed, the hypertrophy will disappear.

Atrophy of the bladder, like hypertrophy, occurs less frequently in women than in men, and most often after the age of fifty years. As a temporary condition it follows extreme distention. It is always associated with fistula and with incontinence, and is a common accompaniment of tumors that press upon the bladder, of malformations, and of habitual retention. If a definite cause can be found, correct it; but in those patients who are over fifty years of age, the prognosis, despite the use of tonics, electricity, etc., is quite discouraging.

Vesical Paresis.

Vesical paresis may be due to some lesion of the brain or spinal cord; it may also result from the general fatty degeneration which is apt to develop in old age. Adhesions binding the bladder to some adjacent organ are competent to produce vesical paresis. When it exists, whatever may be the cause, regular emptying of the bladder by means of the catheter constitutes the essential part of the treatment. Care must be exercised in emptying an overdistended bladder not to remove more than two-thirds of the accumulated urine, and afterward to apply a snugly fitting abdominal binder.

Foreign Bodies in the Urethra and Bladder.

Foreign bodies in the urethra and bladder may be best studied from the standpoint of those introduced from outside the body, and such as are formed or develop within the organ itself—calculi and neoplasms.

Foreign bodies are used by women and children in their efforts to relieve itching due to the following causes: pin-worms around the anus, in the rectum, in the vagina, or hidden under the clitoris; fissure or fistula in ano; vulvar pruritus in diabetes; and irritating vaginal secretions. Libidinous women, in order to gratify a natural passion by unnatural means, intentionally or unintentionally introduce pins, pencils, parasol handles, catheters, candles, needles, matches, glass, tooth-brush handles, etc., etc. The introduction of such bodies is fraught with danger from three sources: (*a*) if repeated, the procedure will lead to dilatation and denudation of the canal; (*b*) if the foreign body is permitted to enter the bladder, it will carrry with it infectious micro-organisms, which are liable to incite cystitis; (*c*) if it should be lost in the bladder, it will form a nidus around which calculous deposits take place.

Calculi.—As the nature and mode of origin of vesical calculi will be treated in detail in other volumes of the HANDBOOK, no further mention of this part of the subject will be required in the present article. The treatment of calculi will be discussed in a later section.

Neoplasms of the Bladder.

Very little is known or has been written in relation to the etiology of new growths of the bladder and urethra.

Age.—Of 89 cases of papilloma collected by F. S. Watson, 59 were males, 30 females. Of the latter there were: between 1 and 2 years of age, 1 case; between 17 and 40 years, 17 cases; over 40 years, 12 cases. Of 100 cases of carcinoma in both sexes, the youngest patient was 30 years old: 12 cases were between 40 and 50, and the rest were over 50 years. On the other hand, of 20 cases of sarcoma collected by Hinterstoisser, the youngest was under 2 years; 5 were under 20 years; 3 were between 20 and 30 years; 2 were between 40 and 50; 6 were between 50 and 60; and 4 were over 60 years of age.

Sex.—Tumors of the bladder occur less frequently in females than in males, the proportion being about 2 to 3.

Mode of Attachment.—As encountered clinically, tumors of the bladder are either pedunculate, sessile, or infiltrating growths. The benign forms (papilloma, fibroma, adenoma, myoma, dermoid and hydatid cysts) show little or no tendency to invade surrounding tissues, this being a distinctive feature of the malignant varieties (epitheliomata, glandular and mixed).

It is generally agreed that non-malignant growths are more common than the malignant forms. Of 640 cases given by Watson, 385, or 60 per cent., were benign. "It is generally believed that of benign growths, papilloma occurs most frequently; next in order is myxoma.

"The *location* of vesical tumors is shown by Feré's table. Analyzing 107 cases, 25 involved the base only; 13 the base and wall; 17 the posterior wall; 8 in close proximity to the left ureter, 5 the right ureter; 2 the anterior wall; 1 the anterior superior wall; 4 the right or left lateral walls; 1 the anterior and superior wall; 12 multiple, and 8 diffuse tumors, etc."

Papillary tumors in the bladder are met with as pedunculate, tufted excrescences, which may be either benign or malignant.

Benign papillomata are made upon a framework of connective tissue, more or less abundant, richly supplied with blood-vessels, and covered everywhere with vesical epithelium. They usually have a tufted, villous, branching appearance, and are so vascular that the name "villous angioma" has been given to them. Sometimes the interspaces between the prolongations are filled with detritus, in which case the fungating appearance is lost. "A frequent form is that of a cauliflower growth, attached by a thin pedicle; others spring separately or in clusters directly from the mucous membrane, in very delicate, thread-like projections. In the sessile form the papillæ are short and thick, and clumped together. The pedicle varies in length from a few millimetres to 3 or 4 cm.; in thickness it may be a mere thread or 1, 2, or 3 cm. in

diameter." In color a fresh growth generally resembles the inner surface of the lip.

Fibroma; Fibro-Papilloma.—It is in this class of neoplasms that the connective-tissue elements preponderate. These growths are less common than those of the former variety, and are infrequently met with in women. The pedicle and mucous surface are richly supplied with blood-vessels. Myxomatous degeneration frequently intervenes.

Malignant Papillomata.—"Papillo-sarcomata usually begin as benign or simple fibroid tumors and pass over to the malignant variety. These tumors are characterized by a dense, fibrous groundwork of very irregular growth, and by the presence in this groundwork of variously shaped cells, generally arranged in different groups. In some there are small, round cells; in others large, irregular cells. The surface of these growths is covered with columnar epithelium, resembling that of the normal bladder. The one feature which differentiates them from the ordinary papilloma is the arrangement of the ground substance, and the presence in it of the irregularly shaped cells, which do not belong to the normal tissue on the one hand, or to that of distinct new growth on the other" (Gibbs quoted by Watson).

Adenoma.—The deficiency of glandular elements within the bladder makes the occurrence of adenoid growths a rarity. An adenoma is sessile or pedunculate, and has a smooth, lobulated, or papillary surface. When sessile, the tumor can be easily enucleated with the finger without hemorrhage. Kelly mentions a case of papillary adenoma that was removed by Kaltenbach, through a vesico-vaginal incision, from a woman forty-four years old. The origin of this tumor was traced by Professor Boström to the mucous crypts of the bladder. Von Fritsch has also described a fibro-adenoma of the bladder in a girl three years old; it was covered with calcareous deposit and filled the whole bladder.

Myoma.—This is one of the rarest forms of vesical tumor; it is made up of hypertrophied muscular coat, with more or less connective tissue, and is covered with intensely congested mucous membrane. These growths vary in size from a pea to a child's head, completely filling the bladder. They may project into its lumen by a very small pedicle or be attached by a broad base.

Cysts.—Follicular cysts, due to occlusion of the mucous follicles, are met with occasionally; they are associated with chronic cystitis. They are readily opened by a spear-shaped knife or by the sharp point of a scalpel. *Dermoid cysts*, as primary growths of the bladder, are almost unknown, but ovarian dermoids have been known to discharge their contents into the bladder, and hair be discharged through the urethra.

Malignant neoplasms of the bladder originate from the connective tissue (sarcoma), from the gland tissue and epithelium (carcinoma), and from degenerative changes in the numerous benign growths (myxoma).

Carcinoma originates from the squamous epithelium of the bladder, (true epithelioma); and from the racemose mucous glands, (glandular-cell carcinoma). Both these varieties present features which characterize carcinoma in other regions: they extend by infiltrating contiguous structures; they project into the bladder as multiple nodules or disseminated patches, often covered with papillary growths or villosities, resembling benign papillomata. The vesical surface may be covered with smooth mucous membrane or it may present a raised, rugged ulcerated surface, with indurated edges. The surrounding bladder wall (muscular and interstitial coats) is considerably hypertrophied.

The disease is most often met with in the lower third of the base of the bladder; it tends to remain confined to the bladder wall rarely involving neighboring organs. According to Clado, its limitation is due in some cases to the presence of a layer of adipose tissue between the cancerous base and the sound tissue beneath. Hoggan explains this as due to the lack of direct communication between the larger portion of the lymphatic channels and the mucous membrane, and he thus accounts for the absence of the infection in neighboring glands, for the tardy extension of the disease, and for the extraordinarily long course which it pursues.

"The carcinomatous area is liable to inflammatory changes, cystic degeneration on its surface or surrounding wall, interstitial hemorrhages, and gangrene in infected cases."

Sarcoma.—But few instances of connective-tissue malignant neoplasms of the bladder have been recorded. "Sarcoma appears about one-third oftener in women than in men, at almost any period of life from early childhood up to fifty-nine years of age. The tissue in which the neoplasm takes its origin is probably the stroma of the mucosa, which ordinarily contains round cells. The tumors are usually multiple, almost always sessile, varying greatly in size, and having, as a rule, a smooth surface; the color is red, violaceous, or even blackish. The parts of the bladder adjacent to the base are usually infiltrated. In women sarcoma is especially prone to extend through the urethra, and appear at the external orifice" (Kelly).

Myxoma.—Myxomata represent the degenerative form of neoplasms, and are always of the compound variety: commonly fibro-sarcomata, myxo-sarcomata, or myxofibromata. "The growth is composed almost entirely of small, round cells of a lymphoid type, embedded in a base, homogeneous, or nearly so, on the surface, but becoming more and more fibrous toward the pedicle, until, at the lowest part, fibrous tissue forms the bulk of the growth" (Watson).

These appear most often in children as single or multiple pedunculated growths, closely resembling nasal polypi. They are first noticed as protruding from the urethral meatus, or as having been expelled therefrom. They manifest a decided tendency to rapid return after removal.

Removal of Neoplasms, Calculi, and Foreign Bodies from the Bladder.

The chief indication, when the presence of a foreign body, a calculus, or a new growth has been diagnosticated, is its immediate removal. This may be accomplished (*a*) through the dilated urethra; (*b*) by colpocystotomy; (*c*) by suprapubic cystotomy; (*d*) by symphyseotomy; and (*e*) by cystectomy.

In selecting the mode of operating heed must be given to the size, shape, and location of the foreign body, or to the facts whether the tumor is pedunculate, sessile, or infiltrating, benign or malignant.

(*a*) *Removal through the Urethra.*—Small calculi, new growths, and other foreign bodies which are not too large to be delivered through the urethra dilated up to 20 mm. are suitable for removal through this canal. Simon advises nicking the posterior wall of the urethra in two places, and has shown that by gradual dilatation by sounds up to 2 cm. the danger of incontinence is avoided. Through a speculum of this size, delicate forceps or the electric wire can be introduced for the complete removal of pedunculate growths and fragments of calculi.

(*b*) *By colpocystotomy.*—"The vaginal route is best when a limited portion of the bladder wall is to be excised with the tumor. It is easier to operate in this way upon the upper portion of the bladder, when the vaginal outlet is relaxed and the anterior wall naturally tends to drop down; it is awkward and difficult to operate with a tight vaginal outlet."

"To make the *vaginal incision* the patient is placed in the left lateral (Sims') position, the perineum is retracted and the cervix fixed with tenaculum forceps; the base of the bladder is then cut through on to a sound introduced through the urethra, and the incision enlarged, if need be, forward to the internal orifice and back to the cervix. The edges of the incision are now drawn apart and the foreign body, calculus or neoplasm, already located cystoscopically, is drawn through the opening into the vagina, everting with it the contiguous portion of the bladder wall. If a tumor, occupying but a small space, it may

now be excised piecemeal, suturing step by step, and, if the bleeding is free, tying the sutures as they are passed. If the area of excision is a larger one, and if the cut goes deeply into or through the bladder wall, it will be best to transfix the wall in several places, at a distance from the field of operation, to hold it in place while the operation and suturing are going on: by so doing the great risk of hemorrhage and delay from the open wound pulling back into the bladder will be avoided.

"If the field of extirpation lies in the neighborhood of the intravesical portion of a ureter, it will be safer to insert a bougie beforehand so as to protect it.

"After removal accurately close the opening at once, with silkworm gut, including all the layers except the vesical mucosa. Drain the bladder for four or five days, and primary union without fistula should take place; inoperable malignant disease may necessitate an artificial fistula."

(c) *Suprapubic Route.*—Hypogastric cystotomy is indicated for the removal of an extremely large stone; it is especially suitable for children, and for the removal of tumors involving the extirpation of any considerable portion of the bladder with the tumor.

Having filled the bladder with water, an incision beginning at the symphysis pubis is carried upward a distance of from 5 to 8 cm. (from 2 to 3 inches) in the median line and the prevesical space exposed. Care must be taken not to enter the peritoneal cavity, and the peritoneum should be pushed upward to avoid infecting that cavity.

Many authors lay especial stress on the necessity of avoiding unnecessary disturbance of the prevesical space and its fat. As a means of avoiding infection, some prefer to displace it downward, others to push it upward.

Entrance to the bladder is secured by a vertical incision, which should be long enough to afford ample space for the necessary manipulations. The insertion on either side of a heavy silk traction suture, passed through the substance of the bladder and abdominal wall, will aid in lifting the organ and will facilitate access to its deepest recesses.

Neoplasms covering a considerable superficial area must be removed by careful dissection, including the muscular coat if that portion is involved by the disease. Nearly the whole of the mucous membrane can be excised, and if strips are left here and there regeneration will take place without materially interfering with the bladder function. Gaps in the mucous membrane should be closed up by continuous catgut sutures, whenever it is possible to do so. Sutures at the base should be tied within the bladder, those at the fundus on the outside; they should not include the mucous membrane.

If the tumor involves one of the ureteral openings, Kelly recommends cutting off the ureter and transplanting it to another portion of the organ. If it is found impossible completely to close the bladder, a gauze drain must be inserted, and later replaced by a small rubber tube.

Transverse Incision.—Antal, of Buda-Pesth, proposed a transverse incision instead of the perpendicular one, access to the bladder being obtained by incising the wall layer by layer. This mode of entrance is of advantage in cases in which the peritoneal fold is found to be "low down." Helferich uses the cross incision in preference to the vertical, and sometimes adds a short cut in that direction, thus giving to the entire incision a **T** shape.

(d) *Symphyseotomy.*—Helferich has used and recommends for certain cases a partial resection of the symphysis, as affording more room and greater facility in reaching the base of the bladder; but this method is seldom if ever required in the female subject.

(e) *Cystectomy.*—Complete removal of the female bladder has been successfully accomplished by von Badenhauer four times, and by Paulik once; but as a rule those in need of so radical a measure are usually in such a low physical condition as to prohibit such an operation.

Neoplasms of the Urethra.

New growths of the female urethra are encountered at all periods of life. They appear most often as polypi, and the spot from which they originate may be located either in the bladder or in the urethral canal. When they originate in the bladder they are forced down by excessive contractile efforts and eventually appear at the meatus or are first recognized when expulsion takes place. Others, arising from some portion of the urethral tube, lodge therein, and are expelled in the same way. The large majority, however, take origin at or just within the external meatus. The marked disproportion between the size of these tumors and the suffering which their presence is capable of inducing, makes it imperative that in every case with pain or discomfort in the pelvis we should determine the exact condition of the urethra.

Urethral caruncle, papillary polypoid angioma of Skene, the most painful and common of urethral new growths, is found at or just within the meatus, usually attached by a slender pedicle, at times by a broad base. It is of a bright red color, spindle-shaped or sessile, and varies in size from a pinhead to a hickory nut. It is composed of connective tissue and hypertrophied papillæ, enclosing bunches of dilated vessels, and covered with a delicate layer of mucous membrane. The pain and suffering induced by these small growths are at times so great as to cause loss of flesh and strength, confine the sufferer to bed, and make life a burden. In other cases pain is experienced only during micturition, but the act is fraught with so much agony as to compel delay, or it makes micturition so nearly impossible as to induce retention, relief being possible only through a catheter, introduced when the patient has been anæsthetized by chloroform or ether. Local anæsthesia or any attempt to approach the external genitalia is absolutely refused by the patient. Sensitive girls and young women, from a sense of false modesty, which prevents them from divulging the seat of the trouble, are the chief sufferers, and it is not a rare thing for one to break down under the strain ere she will confess. The congestion during menstruation will intensify the discomfort.

Condylomata, so frequently found upon the external genitals, may invade the urethral canal, and when they are of recent origin they closely resemble caruncles in shape and color, but differ from them in being insensitive, painless.* Several of the growths are usually present, and they may be found in clusters on the floor of the vestibule, invading the vagina and surrounding the anus. The persons thus affected are, as a rule, uncleanly women who have become infected with the gonococcus of Neisser. Condylomata are composed of a tough network of connective tissue, with dilated capillaries, covered by a more or less dense layer of epithelium, the thickness of which modifies the color of the growths from a bright red to a whitish hue.

Fibromata of the urethra, so-called urethral polypi, are connective-tissue growths. They are of somewhat rare occurrence. They may be encountered at any period of life. A fibroid polyp the size of a fist, attached to the inferior margin of the urethra, was removed from the vagina by Hoening (*Berl. klin. Woch.*, 1869).

Mucous Cysts.—Cysts of the female urethra have been found in a premature fœtus, and at all ages. "In early life they are situated in the meatal portion of the passage, but later in life near the vesical neck. They are usually formed by the occlusion of the orifice of the mucous ducts, and in some cases a black speck upon the surface of the cyst indicates the seat of the orifice."

Varices; Angioma.—Urethral hemorrhoids appear as bunches of worm-like, irregularly distended, dark blue or bluish-red veins, upon the floor of the urethra, at any portion of its length. The swelling, which is at times œdematous in character, occludes the lumen and interferes with the outflow of urine. Sometimes rupture takes place; the blood is poured out beneath the mucous membrane, and later appears at the meatus as a pedunculated mass.

Chancre and *chancroids* are frequently found involving the meatus externus, occasionally both varieties at the same time, and coupled with gonorrhœal infection. Chancre presents itself as a hard, indurated, sometimes ulcerated nodule, upon one side of the meatus, or extending around the greater portion of its circumference, and, if neglected, causes destructive sloughing of that portion of the canal.

"Chancroids of the meatus pursue their usual course, vesication, pustulation, discharge, and present a punched-out, round, irregular or ragged, often undermined ulcer which spreads rapidly, secretes freely, is frankly inflammatory in type, and exhibits an unhealthy diphtheroid, worm-eaten surface, which can be scarcely confounded with any other lesion" (Martin).

Epithelioma originating within the canal is the *rara avis* of the urethra, and some authorities claim that it never occurs in that organ other than as an extension from the bladder, cervix uteri, vagina, vestibule, or the clitoris. The writer has seen three cases of this form of new growth, which involved the whole lumen of the urethra.

Sarcoma.—Kelly was able to find but four cases of sarcoma of the urethra on record, all affecting the external orifice: Beigel's case, a woman of fifty years; and Ehrendorfer's case, a woman of fifty-two years; Galabin's case, a little girl of three years—myxo-sarcoma of the urethra; and Reed's case of melano-sarcoma, occurring in a single woman aged sixty-four years.

The SYMPTOMS of urethral neoplasms depend upon the size, location, and sensitiveness of the growth. Small tumors, other than caruncle, give rise to slight irritability of the urethra, with a tendency to frequent micturition; larger growths exercise a marked influence upon the outflow of urine, either by spasm or by creating an actual obstruction in the canal. Ulceration with hemorrhage, slight in amount and readily controlled, is quite common. Malignant growths, however, break down and bleed profusely; sometimes they produce marked anæmia and loss of flesh and strength. The pain which is incident to spasm, and which is aggravated by voluntary or involuntary retention, may be referred to the back, sacrum, hips, thighs, legs, heels, and suprapubic region.

TREATMENT OF URETHRAL NEOPLASMS.

New growths in the urethra offer but one mode of treatment, viz., surgical extirpation of the most complete character. Pedunculate tumors at or just within the meatus can readily be cut off with scissors, or destroyed by the cautery, or ligated with silk or catgut. Those situated higher up within the tube may be exposed through the endoscope, caught with a tenaculum or small forceps, and amputated by the nasal snare or electric wire. Sessile tumors are best removed by the knife encircling the base, with closure of the gap by catgut sutures. Multiple small growths can be removed with a sharp curette, care being taken not to destroy the mucous membrane of the whole circumference of the canal, for by so doing stricture might follow.

Removal of urethral tumors is easily accomplished under cocaine anæsthesia. A cotton applicator, saturated with a ten-per-cent. solution, will, if placed within the canal and allowed to remain there for five minutes, afford ample anæsthetic effect. In carrying out this procedure the patient is to be placed in the lithotomy position, the bladder is to be emptied, and the external genitals are to be thoroughly scrubbed as for any other operative procedure.

Sessile tumors with broad base, situated high up within the canal, may require general anæsthesia; and it may be necessary, before they can be reached, to dilate the urethra considerably. It is in this variety that galvano-puncture, repeated at intervals of from seven to ten days, has proven so successful in destroying these tumors.

Bleeding after removal rarely amounts to anything more than an oozing, but if the scissors are used to remove polypoid growths and hemorrhage is active, a ligature must be applied.

Caustics for the ablation of neoplasms do not seem to affect the base, recurrences are much more likely to occur, and the danger of stricture is one not to be overlooked.

Malignant growths which do not involve the base of the bladder can be removed, with the larger part of the vestibule, and the labia used to replace the deficiency; but in two cases seen by the writer, incontinence, with excoriation of the genitals and thighs, resulted, and gave rise to almost as much suffering as that caused by the growth. Recurrence took place in both cases within a few months.

INJURIES AND INFLAMMATIONS OF THE BLADDER AND URETHRA.

The intimate relations which exist between the bladder and the urethra on the one hand, and the rectum, vagina, generative organs, parturient canal, abdominal cavity and kidneys on the other, render the former especially liable to injury and infection.

Injuries.—Contusion and laceration of the urethra as the result of rape, attempted or accomplished; violent or too frequent intercourse; intercourse *per urethram;* the intentional or unintentional introduction of foreign bodies, instruments, or the finger; prolonged pressure of the oncoming fetal head; instrumental labor, especially if a calculus lies within the tube or the lower zone of the bladder; the introduction of a hard catheter into that organ—all these are liable to produce a variety of disorders, and to be accompanied by incontinence or partial or total inability to evacuate the urine. Prolonged pressure may so interfere with the circulation as to cause sloughing, gangrene, and such loss of tissue as to impair the structural integrity of the floor of the urethra and bladder. Injury of so grave a character, if associated with infection, tends to a fatal issue.

Gonorrhœal Urethritis.—The introduction into the urethral canal of the gonococcus of Neisser is the most frequent exciting cause of urethritis. The child, during its passage through the birth canal, or later while being bathed, or at the hands of a careless nurse or mother who wipes the genitals with a napkin which she has but recently worn, may be inoculated. Infection may also be conveyed in other ways too numerous to be mentioned.

Gonorrhœal urethritis is said to be less common in women than in men: but the statement must be accepted with some reserve, as the difficulties which stand in the way of ascertaining the facts, in the case of women, are practically insuperable.

As a rule the acute form of inflammation begins in the vestibule or vagina, and, a few days later, invades the urethra, though the latter may be the primary seat, and rarely the only point of infection.

Attention to the urethra is first attracted by a scalding sensation when passing urine. This increases in intensity until the act becomes very painful and ineffective. It is apt to be followed by a slight discharge of blood and an intense and almost constant desire to urinate. The meatus is covered with a cream-like or greenish-yellow secretion, very acrid, which, if the vagina also is invaded, excoriates the vulva, thighs, and anus.

Chronic gonorrhœal urethritis represents the commonest form, and presents characteristic lesions easily noted through the urethroscope. It exists in two forms, described by Kelly as follows:

"1. The *diffuse chronic urethritis* is especially apt to follow on the acute when located in the anterior part of the urethra. It is marked by small abscesses, especially involving Skene's glands, and by a diffuse chronic swelling in the anterior urethra. The funnel wall in these cases is thickened and pouts into the speculum, and the central figure may be displaced laterally. The vessels are deeply injected, giving the mucosa a livid color. The mucosa in older cases presents grayish or slate-

colored patches, 2 or 3 mm. in diameter. The disease is commonest in prostitutes.

"Janovsky states that diffuse hyperplastic processes extend out onto the submucosa from the diseased Skene's glands."

2. *Circumscribed Chronic Urethritis.*—"The subjective symptoms of circumscribed urethritis are mostly slight, often amounting to nothing more than an itching or burning sensation. The discharge is thin and contains but few gonococci; when the disease is localized in the glands it is known as *glandular urethritis* (Oberlander). Patches of deeply reddened mucosa are seen for the most part up near the internal and down near the external orifice. In these, particularly along the posterior wall, groups of yellow spots about half a millimetre in diameter are seen surrounded by a reddened area. In a more advanced stage anæmic streaks of scar tissue may be seen, and the tissue resists the passage of the speculum, even tearing when more pressure is made."

TREATMENT.—During the acute stage, refrain from the use of the endoscope; give demulcent drinks; and keep the patient quiet. As the severity of the inflammation diminishes, and the discharge decreases, examine the urethra, determine the extent of injury to the mucous membrane, and, after cocainization, apply, locally or over the whole canal, pure ichthyol, or silver-nitrate solution (thirty grains to the ounce), every third or fourth day; at the same time applying the same drugs with tampons to the vagina. Inject Skene's ducts with the same solution, or if the inflammation persists, lay them open, and apply iodized phenol to the interior of the gland.

SUBURETHRAL ABSCESS.

"The anterior vaginal wall is the seat of a symmetrically rounded globular swelling, varying in size from a small pea to that of a hen's egg. The abscess cavity is situated in the urethro-vaginal septum, communicating by a tiny opening with the floor of the urethra about one-half to three-quarters of an inch from the meatus externus. The tumor projects into the vagina, is smooth, elastic, and when pressed upon through the vagina, pus is seen to well up into the urethra. It is most frequently met with in married women, during the child-bearing period, who refer to this condition as 'something coming out of the front passage,' and as a source of inconvenience or pain during intercourse. The nature of the enlargement can be readily determined by introducing a fine probe through the urethral opening, disclosing to the finger in the vagina that only the thin wall of the vagina intervenes."

TREATMENT.—The simplest and most efficient way to eradicate a suburethral abscess is to excise an ellipse of tissue, including the vaginal mucosa, and one-third of the sac wall, and apply thoroughly to the interior of the sac iodized phenol, followed by a drying powder, to prevent excoriation of the adjacent structures.

HYPERÆMIA OF THE BLADDER.

The normal trigone presents a more brilliant red color than any other portion of the bladder, and during pregnancy is the seat of increased congestion, with a flushing of the capillaries, quite distinct from hemorrhoidal dilatation of the veins. In addition to these forms of congestion, the trigonal region may present a deep rosy red color which extends to and around the ureteral orifices, rarely beyond, shading into the surrounding structures. In other instances, there are small patches adjacent to one or both ureters, the orifices of the latter being puffy and œdematous, and irregular in outline. Kelly suggests that "a mild infection lies at the bottom of some of these cases, and that the affection is in reality a form of trigonitis, but this remains to be proved."

SYMPTOMS.—The inception of this process is usually quite without warning. There is a sense of unrest, with bearing down, burning, or throbbing in the pelvis; the desire to urinate is more or less constant; the act is unsatisfactory, painless, or painful, and is followed by considerable distress. The bladder is tender on palpation, and the symptoms in the main simulate those of cystitis.

Hyperæmia is associated with concentrated urine and with gonorrhœal urethritis, and it is apt to follow catheterization and abdomino-pelvic operations.

Direct inspection through the urethroscope will at once reveal the true condition. The trigone will appear red; at or near the orifices of the ureters there will be patches which are very sensitive to the touch; and at times there will be a few leucocytes in the urine.

TREATMENT.—Excessive acidity of the urine calls for the use of demulcents and diluents, the avoidance of acid fruits and drinks, the suspension of marital relations; free action of the bowels; and rest. If the irritation does not quickly respond to the foregoing measures, topical applications of silver nitrate (from ten to twenty grains to the ounce) or of ichthyol and glycerin (one drachm of the former to one ounce of the latter) must be made to the inflamed surface, by means of a mop or by instillation, every three or four days.

CYSTITIS.

In cystitis the inflammation involves one or more coats of the bladder. It is brought on by the introduction of pyogenic organisms into a cavity which has been prepared to receive and entertain them. In other words, in the production of cystitis we must have, first, a predisposing cause to prepare the soil (bladder); and, second, an exciting cause, micro-organisms, to develop thereon.

PREDISPOSING CAUSES.—"As predisposing causes of cystitis we recognize and describe such injuries, agencies, and influences as are concerned in establishing a *locus minoris resistentiæ* in the tissues of the bladder in which a sufficient number of pathogenic microbes of adequate virulence accumulate to produce those tissue changes which characterize inflammation. The injured tissues or contents of the bladder furnish the necessary nutrient medium in which the microbes grow. All of the predisposing causes do one of two things or both: 1. They effect tissue changes which determine the localization of the microbes from the bladder, adjacent organs, or the general circulation. 2. They furnish a nutrient medium for the growth and multiplication of microbes."

"The most frequent of all predisposing causes of cystitis is retention of urine from any cause. Retention of urine acts in two ways in predisposing the bladder to infection: (1) The retained urine serves as a culture medium for some of the microbes which are known to produce cystitis; (2) the distended bladder wall is subjected to pressure which in itself is a potent predisposing influence."

"It is time that the medical profession should realize the well-known clinical fact that retention of urine is one of the most frequent and potent conditions in increasing the receptivity of the bladder to infection, and that cystitis can be most effectively guarded against by preventing the accumulation of urine in the bladder beyond the physiological limits. Knowing the great susceptibility of the bladder to infection when the urine is retained, it becomes the surgeon's duty to employ aseptic precautions in the evacuation of the organ by catheterization, puncture, or incision" (N. Senn).

Foreign bodies, tumors, and calculi, by obstructing the outflow, and by causing retention, irritation, congestion, ulceration, and hemorrhage, prepare the soil for the proliferation of any micro-organisms which may find lodgment in the bladder. While the presence of foreign bodies, etc., does not indicate actual cystitis, and while they may for years find lodgment in the bladder without giving rise to actual infection, yet it is a well-established fact that they "are productive of symptoms which lead the surgeon frequently to explore its interior by the use of instruments, a method of examination to which the date of infection can be so often traced." Further, we must not overlook the fact that a certain amount of traumatism is necessarily associated with such instru-

mentation of the bladder and with operations upon that organ.

Compression of the bladder by the pregnant uterus (both before and during labor) and by pelvic and abdominal tumors brings about venous stasis; disease of the kidneys, heart, etc., by obstructing the general circulation, also predisposes the bladder to infection.

Still other pathological conditions render the bladder liable, to an increased degree, to infection. Among them may be mentioned: marked changes either in the quantity of the urine excreted (as in diabetes insipidus and mellitus, in kidney disease, and in hysteria) or in its quality (excessively acid, or, more frequently, abnormally alkaline). Furthermore, the elimination, through the urine, of such drugs as cantharides, turpentine, etc., and the ingestion, for a certain length of time, of stimulating foods and alcoholic beverages, tend to put the mucous membrane of the bladder in a condition favorable for infection.

EXCITING CAUSES.—"The essential or exciting cause of cystitis is invariably the presence and pathogenic action of microbes in the tissues of the bladder, the seat of the inflammation." Pathogenic organisms reach the bladder through the urethra, by the use of instruments, or by direct extension along the surface of the urinary tract. Accurate clinical observations and the results of examination demonstrate that the urine from scarlatina, varicella, typhus, typhoid, septicæmic and pyæmic, and tuberculous patients contains corresponding bacteria, which have been eliminated by healthy kidneys, these organs being themselves uninjured thereby. Suppurative disease of the kidneys, which so often precedes that of the bladder, greatly enhances the danger of infection. Infection may also take place by direct extension from the ureters. Secondary infection may take place from adjacent organs, by rupture of an appendicular, tubal, or pelvic abscess direct into the bladder. On the other hand, infection may take place through migration of the bacillus coli communis, from the intestines, indirectly through the lymphatics. This mode of infection most often results when lesion of the rectal mucous membrane is associated with retention of urine.

Rarely infection takes place through bacteria which are circulating with the blood current and which become lodged in the tissues underneath the mucous membrane, as single or multiple circumscribed foci. This is without doubt the mode of origin of ulcerative cystitis.

CLASSIFICATION OF CYSTITIS.—N. Senn rightly claims that "a rational classification is essential in discussing the etiology, symptomatology, diagnosis, prognosis, and treatment of this disease. The surgeon is no longer content simply to recognize the existence of the disease. To enable him to estimate the gravity of the affection and to adopt an intelligent course of treatment, he must be in possession of accurate knowledge of its real nature, location, and extent. He must know what microbe or microbes have produced the inflammation before he can make a diagnosis that will suggest the necessary therapeutic indications. Mistaken and inaccurate diagnoses are largely responsible for the many shortcomings of our present therapeutic resources. . . . No classification (diagnosis) is complete which does not indicate the anatomical location, the clinical features, pathological characteristics, and bacteriological origin of the disease."

SENN'S CLASSIFICATION OF CYSTITIS.—1. *Anatomical.*—(*a*) Pericystitis; (*b*) paracystitis; (*c*) interstitial cystitis; (*d*) endocystitis.

2. *Pathological.*—(*a*) Catarrhal cystitis; (*b*) suppurative cystitis; (*c*) ulcerative cystitis; (*d*) exudative cystitis; (*e*) exfoliative cystitis.

3. *Clinical.*—(*a*) Acute cystitis; (*b*) chronic cystitis.

4. *Bacteriological.*—(*a*) Bacillus coli communis infection; (*b*) saprophytic (mixed) infection; (*c*) staphylococcus infection; (*d*) streptococcus infection; (*e*) streptococcus erysipelatis infection; (*f*) typhoid bacillus infection; (*g*) diplobacillus infection; (*h*) gonococcus infection; (*i*) bacillus of tuberculosis infection.

CLINICAL DIAGNOSIS.—*Acute Cystitis.*—"That form of inflammation of the bladder in which the symptoms appear suddenly and reach their maximum height in a short time is known as acute cystitis. In this class of cases the infection is intense, the constitutional disturbances are well marked, and the nature of the pathological products in accordance with the acuity of the inflammatory process. One of the best illustrations of what is meant by acute cystitis is furnished by cases of urine retention in which infection occurs by the use of the catheter. The disease is usually initiated by a chill followed by febrile reaction; the urine becomes turbid within twenty-four hours, and in a few days contains large quantities of pus, and ammoniacal decomposition is developed very rapidly. It is not difficult in the majority of cases to establish the existence of acute cystitis, but such a diagnosis no longer satisfies the surgeon who seeks to complete his diagnostic work by investigating the pathological anatomy of the disease and by ascertaining the nature of the infection. Under appropriate treatment an acute cystitis may be under control in a short time, but in the presence of obstructive or visceral lesions the acute symptoms subside in the course of time, when the disease only too often passes into the chronic form."

Chronic Cystitis.—"Chronic inflammation of the bladder is characterized by the absence of acute symptoms, local and general, and the tendency of the disease to persist regardless of the treatment employed. The suppurative form of chronic cystitis is usually complicated by the coexistence of neoplasm, or by the presence of stone or foreign body in the bladder. Cystitis caused by infection from a suppurative affection of the kidneys is also very prone to pursue a chronic course, as the constant irrigation of the bladder with infected pus maintains an uninterrupted source of infection. The best example illustrating the clinical aspects of chronic cystitis is furnished by the *tuberculous variety.* The disease begins insidiously by the appearance of isolated symptoms which point to the bladder as the probable seat of the inflammation. The symptoms gradually increase in number and intensity until the complexus is complete upon which to base a diagnosis of chronic cystitis. The symptoms are often masked by complications which served as predisposing causes or which ensued in consequence of the chronic inflammation. It is in cases of chronic cystitis that an early and correct diagnosis is so seldom made. Renal disease is often mistaken for cystitis, and cystitis for renal disease. It is in such cases that a recourse to all modern diagnostic aids is indispensable for a correct interpretation of the symptoms as they arise. It is well to remember that in the majority of cases of chronic inflammation of the bladder not complicated by obstructive lesions the disease is of a tuberculous nature.

ANATOMICAL DIAGNOSIS.—(*a*) *Pericystitis.*—Inflammation of the adjacent pelvic or abdominal viscera may also involve the peritoneum covering the fundus of the bladder, though more frequently its base and sides are affected. When the inflammation surrounds the vesical ends of the ureters, these are likely to become obstructed by cicatricial contraction of the inflamed tissues.

Dasheux believes that the "irritable bladder" in women is due to localized hyperæmia of the mucous membrane, seen as patches at the base of the bladder, less often at the neck. Congestion of the uterus and adnexa generally stands in a causal relationship to this vesical hyperæmia. Kolischer describes, in connection with such cases, a peculiar form of œdema of the mucous membrane of the bladder observed through the cystoscope; it appears in the form of circumscribed blisters the size of a pea, the rest of the membrane being normal.

This pathological condition is always associated with pelvic exudates, and is most frequently seen in women who are the subjects of salpingitis.

The symptoms which attend this form of vesical irritation are painful urination, tenesmus, and a feeling of weight and pressure over the bladder.

(*b*) *Paracystitis.*—Paracystitis is an inflammation of the subperitoneal connective tissue in that part where the

bladder is extra-peritoneal. At the base of the organ there is a paracystitis, while in front the disease usually appears in the form of a phlegmonous inflammation of the loose connective tissue. In both of these locations abscess formation is the usual termination of the inflammatory process, an occurrence which is always attended by distressing bladder symptoms. Abscesses in both of these places, unless incised early, are very prone to rupture into the bladder, an accident which is often followed by an obstinate cystitis. Inflammation of the subserous connective tissue, following infection through the lymphatic channels, is a very obscure affection, and a positive diagnosis is more frequently made in the post-mortem room than at the bedside. The formation of multiple abscesses in such cases is not an unusual occurrence. More or less pericystitis is almost always associated with paracystitis involving the intraperitoneal portion of the bladder.

(*c*) *Interstitial Cystitis.*—Interstitial cystitis involves the middle or muscular coat of the bladder. Infection reaches this coat, which is the seat of the most numerous lymph channels, either by secondary extension from some adjacent inflammatory focus, or directly from the mucous lining; much more rarely it is conveyed by way of the circulation. In either case it usually leads to a diffuse inflammation involving the whole middle coat, which becomes elevated into greatly thickened rugæ and can be felt by the sound. The small abscesses rupture into the bladder, leave diverticula, heal slowly, and often form recesses for stone. Following this form of cystitis the bladder undergoes marked diminution in size through cicatricial contraction. In the embolic form of interstitial cystitis, circumscribed inflammation and abscess formation are the results of infection.

(*d*) *Endocystitis.*—Cystitis proper, as the term is usually applied, refers to an inflammation of the mucous membrane of the bladder. Such an inflammation may be limited to the trigonum, to the urethral or to the ureteral orifices, from which points diffuse cystitis has its origin. The inflammation may almost from the beginning involve the whole mucous surface. Inflammation of the neck, the most sensitive portion of the bladder, gives rise to the most distressing symptoms. In cystitis proper the urine contains, almost from the beginning, the morphological elements of the inflammatory products—blood, epithelial cells, and pus corpuscles—the presence of which always constitutes an important distinguishing feature between endocystitis and the other anatomical varieties of inflammation of the bladder.

PATHOLOGICAL DIAGNOSIS.—"The effect of microbes and their toxins on the tissues of the bladder varies according to the specific pathogenic effects of the original bacteria, the number of microbes, and their degree of virulence. The inflammatory product is also greatly influenced by the condition of the urine and the nature and extent of the predisposing causes."

"The pathological classification must be based entirely on the character of the inflammatory product: cystitis, endocystitis, or cystitis proper being taken as the type of the disease."

(*a*) *Catarrhal Cystitis.*—"From a modern pathological standpoint catarrhal cystitis is a term used to indicate the existence of a superficial inflammation of the interior of the bladder in which the epithelial cells furnish the principal part of the morphological elements of the inflammatory product. It is, like all catarrhal inflammations in other localities, a surface affection. The mucous membrane is swollen and red, and the inflammatory process consists in increased exfoliation of epithelial cells and the formation of mucous in abundance. If the disease become chronic, thickening of the mucous membrane and secondary infiltration of the muscular coat lead to hypertrophy of the bladder wall. Retention of urine aggravates the inflammation and increases the vesical distress. Erosions and superficial ulcerations may develop during the course of the disease. The urine is usually acid, and contains pus and an abundance of bladder epithelium. In cases in which the urine has undergone alkaline decomposition the inflamed surface presents a dirty whitish deposit of muco-pus."

(*b*) *Suppurative Cystitis.*—"Suppurative cystitis appears clinically as a diffuse affection, in which not only the epithelial lining but also the deeper structures are generally involved. The microbic infection is of sufficient intensity to destroy the protoplasm of the morphological products of the inflammation (white corpuscles purely epithelial, and connective-tissue cells), and transform them into pus corpuscles. The urine contains large quantities of pus and bladder epithelium. During the acute stage small fibrinous patches appear upon the inflamed surface. Ulceration differing in extent and depth is of common occurrence. Deep necrosis may lead to perforation. If the urine is ammoniacal, the necrosed patches present a grayish-white color and are encrusted with sand-like deposits. The decomposition of the urine is generally due to other microbes than those which have caused the suppurative inflammation; that is, it is generally the result of mixed infection. Besides the usual pyogenic microbes, the ammoniacal urine contains some species of saprophytic bacteria or the diplococcus ureæ. Suppurative cystitis generally begins as an acute inflammation, but is very likely to pass into the chronic form, and direct extension of the infective process is liable, sooner or later, to implicate the kidneys."

(*c*) *Ulcerative Cystitis; Simple Ulcer of the Bladder.*—"In this class of cystitis it is not my intention to include the cases of suppurative cystitis which terminate in ulceration, which would only indicate an advanced stage of the disease, but I desire to limit the application of the qualifying term ulcerative to a form of cystitis in which ulceration takes place almost from the beginning of the inflammation. In cases of this kind the infection appears to be of a peculiar kind, limited in extent, and the resulting inflammation leads quickly to a circumscribed destruction of tissue, the formation usually of a single circumscribed ulcer, the so-called simple ulcer of the bladder. This form of cystitis is quite rare, and resembles in many respects gastric ulcer and the round duodenal ulcer."

(*d*) *Exudative Cystitis.*—"Inflammation of the mucous membrane of the bladder accompanied by the deposition, upon the inflamed surface, of the products of coagulation necrosis should be called exudative cystitis. The descriptive terms, membranous, diphtheritic, croupous, and fibrinous, are confusing and misleading and should be excluded from the present nomenclature in the description of this pathological form of cystitis. The exudate consists largely of fibrin, and is variously modified in quantity and appearance by the character of the infection and the condition of the urine. The exudate is the best possible proof of the severity of the infection and intensity of the inflammation. It proves the existence of a deep-seated lesion and great damage to the blood-vessels in the inflamed tissues. This form of cystitis is most frequently observed in puerperal women and women suffering from pelvic tumors large enough to subject the bladder to harmful pressure."

"Savor ('Cystitis crouposa bei saurem Harn,' *Wiener klinische Wochenschrift*, 1895, No. 44) observed a case of exudative cystitis on the fourth day after extirpation of the uterus by the abdominal route. The catheter was not used either before or after operation. Membranes 5 or 10 cm. in length were expelled with the urine. These membranes were composed of fibrin and contained in their meshes numerous pus corpuscles. The urine was ammoniacal only for one day. In the urine sediment the colon bacillus was found, and was regarded by the author as the essential microbic cause of the inflammation. Savor made experiments with pure cultures of this bacillus with a view of reproducing this special form of inflammation upon serous and mucous surfaces of other organs in animals, but the result of his endeavors proved negative. The urine in exudative cystitis is usually alkaline, and Savor believed that in his case it remained acid after the first days owing to the absence of a mixed infection. In the majority of cases exudative cystitis occurs in women during the child-bearing period, and positive proof

of the pathological nature of the cystitis is always furnished by the expulsion of membranes or shreds of fibrin with the urine."

(*e*) *Exfoliative Cystitis.*—"Exfoliative cystitis is an inflammation of the bladder in which almost from the very beginning the toxins of the microbes which produce the disease destroy the mucous membrane and sometimes even the muscular coat, which, if the patient survive, become detached with the inflammatory products and are expelled with the urine, or in some instances have to be extracted by the surgeon. This is the most dangerous form of cystitis, and can occur only as the result of the most virulent infection, aided in most cases by local predisposing causes. In exudative cystitis the toxins precipitate the inflammatory product by causing coagulation necrosis; in exfoliative cystitis they cause necrosis of the mucous lining of the bladder and occasionally also of the muscular coat. The same mechanical causes which are so influential in exudative cystitis are usually present and active in the production of the exfoliative forms.

"The differential diagnosis between exudative and exfoliative cystitis can be made only by a careful study of the membranes, shreds, or masses expelled or removed from the bladder, which often must necessarily include the use of the microscope as a diagnostic aid" (Senn).

BACTERIOLOGICAL DIAGNOSIS.—The most modern views on the etiology of cystitis place microbes in the first rank, relegating all the other causes to the grade of predisposing factors. From this standpoint it behooves the diagnostician to consider well the identification of the particular microbes which are at work, not only to emphasize his diagnosis, but to point out clearly an appropriate course of treatment.

While on this quest it is necessary to keep in mind that the bladder wall, under normal conditions, is very tolerant of the presence, even in large numbers, of a single species of micro-organism; that it can for a long time harbor new growths and foreign bodies without any or with but slight protest; that it may be subjected to disturbances in its circulatory apparatus, to traumatic insults, etc., and give but temporary evidences thereof, until there are added certain pathogenic microbes, the *sine qua non* of any form of cystitis. A brief consideration of these will now be in order.

The *bacillus coli communis*, that constant inhabitant of the intestinal tract, and most common of all denizens of the bladder, when alone, floating in an acid medium, refrains from breaking up urea. Melchior found that the bacillus coli was present in every instance in which the urine was acid.

Saprophytic (Mixed) Infection.—"In more than one-half of the cases of acute and chronic cystitis, infection is the result of the presence and combined action of two or more kinds of microbes. Pus microbes and the saprophytes decompose urine, rendering it alkaline. Ammoniacal urine acts as an irritant to the mucous membrane of the bladder, producing textural changes, and prepares the way for the action of the bacteria which are more directly concerned in the production of the inflammation. A mixed infection must be suspected in all cases in which the urine is ammoniacal. Gas formation (pneumaturia) occasionally takes place from the presence of the bacillus lactis aërogenes (Heyse) and the bacillus aërogenes capsulatus of Welch. The experiments of Schnitzler show that the decomposition of urea and the putrefaction caused by microbes are often greatly influenced by the composition of the urine; gas being produced only in those with diabetic urine. Saprophytic infection is almost always associated with urine retention, and may precede or follow infection with the microbes which are the essential cause of suppurative cystitis. It is in such cases that careful systematic irrigations of the bladder prove of such eminent value in correcting the alkalinity of the urine and in arresting the suppurative inflammation" (Senn).

Staphylococcus Infection.—"The staphylococcus pyogenes albus and aureus, the microbe most frequently found in all suppurative affections, has been often demonstrated as a solitary microbe, and in association with other pyogenic microbes and saprophytic bacteria in the urine of patients suffering from catarrhal and suppurative cystitis. The staphylococcus is a comparatively mild microbe, and its presence as a sole microbic cause should be suspected in inflammatory affections of the bladder in which the infection does not penetrate deeply, and in which the urine shows no evidences of exfoliation. In staphylococcus infection the urine may be ammoniacal without the presence of saprophytic bacteria, as pus microbes, when present in large numbers, decompose the urea, besides lighting up the suppurative inflammation" (Senn).

Streptococcus Infection.—"That the streptococcus pyogenes is not often the cause of cystitis becomes apparent from a bacteriological examination of the urine from six cases of inflammation of the bladder made by Huber (*Correspondenzblatt für Schweizer Aerzte*, October, 1893). He found this microbe only once; in the remaining five cases the bacillus coli communis" (Senn).

"Melchior found the urine acid in all cases of cystitis in which the streptococcus was found as a solitary microbe. It is well known that the streptococcus generally produces a diffuse form of inflammation, during which the connective tissue is often destroyed by the toxins and is later eliminated or removed in the form of shreds. The streptococcus invades the lymphatic channels and connective-tissues spaces, and is almost constantly found in phlegmonous inflammation and diffuse abscesses. A streptococcus cystitis is characterized by the intensity of the local and general symptoms and by more or less destruction of the tissues of the bladder wall. The presence of this microbe may be surmised in cases of diffuse interstitial and exfoliative cystitis" (Senn).

Erysipelatous Cystitis.—"Infection of the bladder with streptococcus erysipelatis is extremely rare, but there can be no doubt of the possibility of such an occurrence" (Senn).

Typhoid Infection.—Melchior reports a case of typhoid infection of the bladder in a male convalescent from typhoid; but no such case has been met with in females.

Diplobacillus Infection.—"The diplobacillus of Friedländer, which has been found in so many suppurative lesions complicating or following pneumonia, in rare instances has been found as the only microbic cause of cystitis. The urine contained pus, a small quantity of albumin, and diplobacilli" (Senn).

Gonococcus Infection.—Infection of the bladder due to the extension of gonococci from the urethra as a solitary infection does at times take place, but in the majority of cases these microbes are associated with some other species. Gonorrhœal cystitis presents itself more frequently in the form of a trigonitis, as a localized affection with a tendency to become diffuse and to extend to the kidneys. Wertheim, in a girl nine years of age, excised, through the cystoscope, a piece from the bladder mucous membrane, and found therein an abundance of gonococci, some between the epithelial cells, some having produced thrombosis in the capillaries and veins.

Tuberculous Cystitis.—"Tuberculous cystitis furnishes the best clinical representation of chronic cystitis. With few exceptions, a primary chronic cystitis is of a tuberculous nature. It is important to bear this in mind in the examination of all cases of cystitis in which the initial symptoms point to a chronic inflammatory process."

"Tuberculosis of the bladder is caused either by infection with the bacillus of tuberculosis through the blood, by extension of a tuberculous process by continuity of surface from the kidney or the genital organs, or by the rupture of a tuberculous abscess into the bladder. Vesical tuberculosis is found more frequently in males than in females, and is usually a disease of early and middle life. Localization of tubercle bacilli in the mucous membrane of the bladder, like that of pyogenic and saprophytic bacteria, is favored by antecedent affections of the urinary tract. Primary tuberculosis from infection through the blood is so rare that König doubts its existence. Infection takes place most fre-

quently from the kidneys. The resistance of the mucous membrane of the bladder to tubercle bacilli is great. In many cases tuberculosis of the kidneys may exist for several years without affecting the bladder. The mucous membrane of the bladder can be irrigated with urine containing tubercle bacilli for years without becoming tuberculous. Clado pointed out that tuberculous granulations in the bladder do not, as is claimed by some authors, occupy the submucous tissue, but the mucous membrane itself—that is, the subepithelial layer. He believes that this is due to the presence of a well-developed capillary network in the mucous membrane, which determines localization of the bacilli floating in the general circulation. Secondary infection occurs most frequently from the kidneys, by extension along the urethra, and from there to the bladder. A previous gonorrhœal cystitis not infrequently prepares the soil for tuberculous infection. König observed a case in which turpentine intoxication first produced active symptoms in a case of latent catarrhal tuberculous cystitis caused by a tuberculous kidney" (Senn).

"No age is exempt. The writer has seen, in a girl nine years of age, a case of primary vesical tuberculosis that extended to both kidneys and proved fatal in less than a year" (Senn).

"The two places where tuberculosis of the bladder is most likely to commence are the ureteral orifices and the trigone of the bladder. The former starting-point of the disease is the rule when the bladder becomes involved by a descending tuberculous ureteritis—that is, when the disease is secondary to renal tuberculosis: the trigone is usually the original seat of the disease in primary tuberculosis of the bladder" (Senn).

"The tuberculous disease here as elsewhere is characterized by the same chain of pathological changes—infiltration, caseation, and ulceration. Penetration of the bladder wall frequently leads to the formation of perivesical abscess and fistula formation, a part or all of the urine escaping through the fistulous opening. The chronic inflammation and the vesical tenesmus lead to great thickening of the wall of the bladder, sacculation, and diminished capacity of the organ. The extension of the tuberculous inflammation over the surface and in the direction of the different tunics of the bladder wall is hastened in case the bladder becomes infected with pus microbes, which is so often the case, and which is so frequently caused by the needless use of instruments in the fruitless search for stone in the bladder, which a beginning vesical tuberculosis often mimics so closely. The complications most frequently encountered in post-mortem examinations of patients who have died of the direct or indirect effects of tuberculosis of the bladder are tuberculosis of the lungs, kidneys, genital organs, and peritoneum, and perivesical tuberculous abscesses with or without fistula formation. The disease is initiated by a frequent desire to urinate, by pain after emptying the bladder, with slight hæmaturia at longer or shorter intervals. Urination becomes more frequent as the disease advances, and after the neck of the bladder has been reached incontinence of urine becomes a conspicuous clinical symptom. The urine exhibits the same appearance and contains the same morphological constituents during the early stages of the disease as in cases of chronic catarrh of the bladder. In the beginning of this disease the urine is acid and contains pus, bladder epithelia, and a small quantity of albumin. If the kidneys are affected at the same time, the albumin is more abundant. If secondary infection with pus microbes or saprophytic bacteria has occurred, it is alkaline in reaction and often ammoniacal, and then contains also a larger amount of mucous and pus corpuscles and disintegrated red blood corpuscles, besides the large flat epithelial cells from the bladder. As soon as the cheesy material on the surface of the bladder softens and disintegrates, fragments of detritus are found in the urine. Tubercle bacilli are not always present, and their detection is often very difficult. Their presence can also be determined by cultivation on artificial nutrient media and by inoculation experiments. If, in cases of suspected bladder tuberculosis, the bacillus cannot be found, the injection of a few drops of the urine sediment into the eye, a joint, the pleura, or the peritoneal cavity of a rabbit or a guinea-pig will often succeed in reproducing the disease, and upon the results of such experiments we must then base our diagnosis. The positive results of such experiments and the detection of bacilli in the urine do not enable us always to locate the disease anatomically; in other words, we must ascertain further whether the disease involves the kidney, the bladder, or the lowest portion of the urinary tract. Nitze's cystoscope is a useful diagnostic instrument in the hands of experts. Finally, it may be stated that in all chronic inflammatory affections of the urinary organs it is necessary to make careful and often-repeated examinations, both of the general and local symptoms, for the purpose of locating the disease, as well as to determine its nature, which often can be done in a satisfactory manner only by making a microscopical and bacteriological examination of the urine. If this should still leave the diagnosis doubtful, a resort to inoculation experiments upon animals susceptible to tuberculosis becomes necessary as a decisive diagnostic test" (Senn).

THE DIAGNOSIS OF CYSTITIS AND URETHRITIS.—The diagnosis of vesical and urethral disease involves a careful study of the whole genito-urinary tract and of the pelvic organs.

Thus in a given case, pointing to trouble in the bladder or urethra, perhaps to both, we are called upon to determine the location of the disease, the character of the lesion, the source of the infection, and the conditions which make the organs susceptible to such invasion. These factors we arrive at by carefully reviewing the history, by a thorough physical examination of the patient, and by an exhaustive study of the urine.

1. The *history* in most instances lacks characteristic features, but pain and abnormal micturition are common to all cases.

Pain.—During the acute stage of bladder infection pain is the one constant and most distressing symptom, corresponding to the intensity of the disease. It is located in the bladder itself, is least intense just after urination, increasing as the bladder becomes distended with fluid, and reaches its maximum as the filled organ begins to contract preparatory to expelling its contents.

As the acuteness of the attack subsides, the relations of the pain to the local condition of the bladder and to micturition are more marked. Inflammation of the base will give pain when in the erect posture, which lying down will, for a time at least, relieve, until the bladder fills, contraction begins, the organ is emptied, and for a short period rest is secured.

The pain of urethritis and cystitis is frequently referred to the rectum, vagina, along the thighs, and the lumbar and sacral regions, and is spoken of as a heavy, burning pain, not unlike that of pelvic inflammations, peritonitis, etc. It often puzzles the surgeon to determine just which of these conditions contributes most to bring about the suffering.

Abnormal Micturition.—Under normal conditions, the average capacity of the bladder varies, in adults, from 250 to 700 c.c. (℥ viij. to xx.). The organ empties itself from three to six times in twenty-four hours; but the urine may, within the limits of health, be subject to wide variations in its chemical constituents and in the quantity excreted, and these factors modify the frequency of expulsion.

Urination, according to Bryant, is modified as to the length of time between the acts, as to the length of time associated with the act, as to the effort necessary to perform the act, and as to unnatural sensations connected with the act.

The length of time between two acts of urination may be shortened by any influence, direct or reflex, that exaggerates the normal sensation which stimulates the bladder to contraction. Any source of intravesical irritation, urethritis, mental emotions, inflammation of the

spinal cord, chronic or acute, abdominal tumors, adhesions of the pelvic viscera, injuries, disease, and operations upon the rectum, perineum, or pelvic organs, changes in the quality and quantity of the urine—each and all induce undue excitability of the evacuating centres or, by modifying the capacity of the bladder, shorten the normal interval between the acts.

Infrequent Micturition.—An abnormal prolongation of the time between the acts may be brought about by any influence which blunts or destroys the normal desire to urinate, or impairs or delays the motor influences which accomplish the act. Free perspiration, the ingestion of a small quantity of liquids, the stupor of fever, kidney disease with diminished secretion, associated with but little change in the specific gravity of the fluid secreted, may fail to excite contraction of a full bladder. In persons of indolent habits, in those who are confined to their beds, and in women who habitually refrain from responding promptly to the calls of nature, the bladder acquires the habit of slow response to stimulus.

Retention of Urine.—Retention of urine may be defined as the accumulation of an abnormal quantity of urine, from failure to empty the bladder within a reasonable period. It is associated with inability to micturate voluntarily, necessitating the use of artificial stimulants, heat or cold, anæsthesia, or the introduction of a catheter to empty the bladder.

Inability to urinate most often results from the presence of some mechanical obstruction within the bladder or urethra, as in blocking of the vesico-urethral opening by calculi, foreign bodies, blood clots, mucous plugs and pus, and when neoplasms, urethral stricture, congenital stenosis, compression of the urethra by a pregnant uterus, abdominal tumors, etc., exist.

Acute overdistention is characterized by paresis of the muscular wall of the bladder, and if oft repeated, whether voluntarily or otherwise, it will lead to atony of the muscle and retention.

The excessive pain associated with passing urine, in inflammation of the trigone or the urethra, and especially when a caruncle is present at the external meatus, will induce a patient to refrain from voluntary urination. Neurasthenic females feign inability to urinate from a morbid desire for catheterization. Fear, fright, severe mental emotion, and the stupor and relaxation following operations and shock may cause retention.

Overflow.—When the bladder has become distended to its utmost capacity, urine will escape drop by drop or as a constant dribbling discharge. This overflow is often mistaken for incontinence.

Uncontrollable Micturition.—In an otherwise healthy woman prolonged abstention from urinating, with overdistention of the bladder, will often provoke such a demand to urinate as to be wholly beyond control. The hypersensitiveness of acute cystitis will frequently instigate such unduly active contractions of the bladder as to render the act imperative. On the other hand, although the call to urinate may be strong, the desire is not beyond control. This condition of urgent micturition frequently accompanies cystitis. It more commonly arises from causes indirectly connected with the bladder, as polyuria, irritating urine, and moderate overdistention from neglect or preoccupation; it may also result from mental impressions, such as those caused by running water, fear, fright, cold, etc., all of which may excite reflex contraction of the viscus. Urgent micturition is an important sign of rupture of the bladder and also points to inflammation of the urethra.

Interrupted Micturition.—Any movable foreign body, neoplasm, clot, or mucous plug, within the bladder, may be carried by the outflowing stream against the outlet, and by a ball-valve action close it, interrupting the stream. During efforts to relieve an involuntarily overdistended bladder, the current may be suddenly intercepted, and then as suddenly resumed, owing to a partial restoration of the muscular power. Frequent repetition of this condition will lead to difficult micturition.

Retardation or *delay* "in starting the stream" occurs from the presence of an obstruction within the urethral canal—swelling, œdema, or varices in the canal or at the outlet,—from abrasions of the mucous membrane, from tenesmus, from fear of pain during the act, from the presence of an obstructing body at the internal orifice, and from atony following hyperdistention. It also happens as a result of diminished vesical power caused by special nerve lesions, independently of local disease; from shame, and also when the general sensibility is blunted, as in the case of shock, narcosis, and asthenic disease.

The effort necessary to perform the act of urination, under normal conditions, involves only a voluntary suspension of the sphincter control in response to the command of a well-filled bladder.

Difficult micturition is attended with and necessitates an increased effort to overcome the coincident fear and apprehension.

Incontinence of Urine.—Inability of the bladder to restrain the escape of its normal contents may arise from malformations of the urethra, such as an abnormal opening of the bladder into the vagina, direct implantation of the ureters (one or both) into the urethra, extroversion of the bladder; it also accompanies organic disease of the central nervous system, such as idiocy, cerebral palsy, acute meningitis, brain tumors, certain forms of myelitis and injuries of the cord. Want of control of the discharge of urine may be due to one of the numerous forms of fistulæ communicating with the vagina, or to dilatation or dislocation of the urethra, and may be simulated by the dribbling of retention.

Enuresis.—The bed-wetting habit of young children may be classed as independent of any disease, and is usually met with in neurotic children, or those whose early training has been neglected. Children can be taught to control the bladder before the first year, certainly within the second year. Holt says: "If a child during its third year cannot control the evacuation of the bladder during its waking hours, incontinence may be said to exist."

Painful Micturition.—Pain or discomfort *before* urination is due to the irritating effects, upon an inflamed vesical mucous membrane, of abnormal urine. Pain during micturition may be due to the condition just mentioned or to some form of urethral inflammation, to ulceration, or to the presence of neoplasms in the canal or at its meatus. This pain, which is described as of a burning, smarting, or stinging character, ceases at the end of or shortly after urination. Pain *at the close of or after* micturition follows the evacuation of an overdistended bladder or the impact of a stone or new growth within the grasp of the inner outlet, causing spasm at that point.

2. A *physical examination* in suspected cystitis must include percussion, palpation, and inspection. Percussion of the suprapubic region, when the bladder is distended, will elicit a dull note, if it is filled with urine; a tympanitic note if it is filled with air. The distended bladder may extend to the umbilicus, and has been mistaken for the pregnant uterus, for cystoma, and for other abdominal tumors. If in doubt, pass a clean catheter.

Palpation of the urethra can be accomplished by introducing the index finger into the vagina and moving it from side to side while pressing in an upward direction. In this way it is possible to ascertain whether there is any thickening of its walls or any appreciable tension; whether the pressure causes pain; and whether a calculus or a foreign body, a polypus, a suburethral abscess, or a prolapse of the inferior urethral and bladder walls is present. The external urethral orifice, on the other hand, can best be examined by inspection and palpation. Separating the labia minora exposes the vestibule and meatus. The latter is not always readily distinguished, unless the vestibule is made tense laterally, when the orifice comes into view, exposing whatever pathological condition may be present: pus, a bright red, sensitive caruncle, the openings of Skene's ducts just within the canal, on either side, a hard infiltrating cancer, a chancre, or, more frequently, a chancroid involving part or the whole circumference of the meatus. Next retract, later-

ally, the labia majora, and instruct the patient to strain down as when at stool, in order to expose the anterior bladder wall, and thus to make it possible for the examiner to determine whether or not a cystocele is present. Expose the clitoris, noting any adhesion of the preputium, and release it if adherent.

By means of abdomino-vaginal palpation, a variety of pathological conditions, either of the bladder or of neighboring organs, can be ascertained. Among these may be mentioned the following: a calculus or a foreign body in the bladder; thickening of the walls of the bladder, as in tuberculous cystitis; thickening of its muscular coat due to an obstruction to the escape of the urine; inflammation of the bladder, as shown by hypersensitiveness; pelvic tumors or collections of pus; uterine displacements, etc.

Kelly says: "A still better way to palpate the bladder bimanually is to put the patient in the knee-breast position, and, letting air into the vagina, the fingers of both hands can be brought close together and the whole organ be felt with wonderful distinctness."

Palpation of the ureters through the vagina or rectum determines the condition of their vesical extremities. "The index finger is carried high up into one of the vaginal fornices, pushing it upward and outward toward the pelvic wall, which is then gently stroked downward and backward. The ureter feels to the finger tip like a flat cord which is constantly slipping away. The cord is palpated again and again, each time bringing the finger nearer the outlet, and so tracing the course of the ureter down the pelvic wall to the point at which it passes between the anterior vaginal wall and the bladder.

"Sometimes the ureter will be found lying close to the pelvic wall, and at other times in the loose cellular tissue several millimetres distant.

"In palpating its lower extremity the ureter is distinguished by its direction, its size, its consistency, and its mobility. It may be confused with an obturator artery pursuing a course parallel to the vagina, but the artery is small and round, and it will be felt to pulsate. The obturator nerve also lies parallel to the course of the ureter above, but it may be traced down to the obturator foramen, and produces pain in the leg on pulling it. The sharp tendinous arch of the levator muscle may be also mistaken for the ureter, but a close palpation will correct this source of error, as well as the impression at first produced by strands of the internal obturator muscle.

"The normal ureter can only be palpated with certainty through the intact abdominal walls at the pelvic brim when the walls are extremely thin.

"When making this examination the surgeon places the patient on her back with the shoulders raised on a pillow and the thighs drawn up, and the large bowel and the bladder empty. The examiner stands on the side he wishes to palpate and begins by making a gradually increasing deep pressure through the abdominal walls until the promontory of the sacrum is found; 3 cm. (one and one-quarter inches) to the right or left of this point and a little below it is the point at which the ureter crosses the pelvic brim. By making deep pressure through the semilunar line over the brim at this point in an oblique direction from above downward, and sliding the fingers up and down, the patient will at once complain of pain and possibly a desire to urinate if the ureter is inflamed. A large diseased ureter—tuberculous, for example—will feel through a thin abdominal wall like a stout cord rolling under the fingers.

"The abdominal portion of an inflamed ureter above these points may be traced by following the line of tenderness developed on making deep pressure.

"By rectum the ureter can be felt from the pelvic brim to the pelvic floor through the empty bowel; the left ureter is the most accessible. The pelvic floor is invaginated by strong pressure and the finger carried up to the bifurcation of the common iliac artery, from which point down the internal iliac artery is easily followed. Guided by these landmarks, the finger palpates carefully behind and close to the internal iliac artery until a flat, yielding cord (the ureter) is detected, which can be traced at first downward then forward. A ureter whose walls are thickened can be still more readily found and palpated. If the ureter is not found in this way, it can be palpated with perfect ease throughout its pelvic course by first placing a hard-rubber bougie or a catheter within it" (Kelly).

Digital dilatation and examination of the urethra cannot too strongly be condemned.

Rectal exploration should always precede instrumental examination of the bladder and urethra, as not infrequently, on removal of a polypus from the rectum, or after the radical cure of hemorrhoids, fissure, fistula in ano, or ulceration and stricture, bladder and urethral symptoms will at once disappear.

Direct inspection of the urethra (urethroscopy) and bladder (cystoscopy) affords the most convincing evidence of the true nature of disease within those organs.

Due precautions must be exercised to have the external meatus thoroughly wiped clean; all instruments should be boiled in a two-per-cent. soda solution; the hands of the operator should be prepared as for an operation; and every means should be taken to avoid introducing what may prove to be the spark to light up an inflammation, which, if it does not cost the patient her life, will require months of anxious care to eradicate.

The introduction of the speculum is contraindicated during the active stage of gonorrheal infection.

Urethroscopy—Endoscopy.—Direct inspection of the urethra is accomplished by introducing into the bladder a cylindrical speculum 6 to 8 or 10 mm. in diameter and gradually withdrawing it, all the while studying the urethral mucosa as each portion closes over the end of the speculum, from within outward. At first the sharp edge of the internal orifice is seen to close over the end, in pupil-like fashion; next the picture resembles a funnel (Grunfeld) the apex of which has been named the "central figure"; the flanging portion of the "funnel wall" being made up of from eight to twelve folds which radiate from the central figure to the margin of the speculum. The posterior fold in the upper part of the urethra is the largest and is a continuation of a triangular elevation on the trigonum in the bladder, named by Barkow *colliculus cervicalis*.

Many delicate vessels are plainly seen on the urethral walls, one or two on each fold running longitudinally with it. In the lower part of the urethra, near the external orifice, the longitudinal folds are crossed by a transverse fold, which subdivides the urethral mucosa into a kind of latticework with shallow pits between.

"The orifices of the urethral glands, Morgagni's crypts and Littré's acinous glands, appear as fine points, often in groups disposed longitudinally, or as larger yellowish spots; they can be better seen by changing the position of the speculum so as to displace the central figure and bring one side of the urethral wall flat against its end" (Kelly).

Microscopic examination of stained specimens should be made in every case of purulent urethritis, not only to establish the diagnosis but to furnish data upon which to base a correct prognosis.

Cystoscopy.

As representing the simplest and best method of direct inspection of the interior of the bladder and urethra, we present the so-called "postural method" of Prof. Howard A. Kelly, first described by him in the Johns Hopkins Hospital Bulletin, November, 1893. The fundamental principles of this method are:

1. The introduction of a simple cylindrical speculum into the bladder.

2. The atmospheric distention of the bladder induced solely by posture.

3. The illumination and inspection of the vesical mucosa, either by means of direct light, such as a little electric light attached to the forehead or the mouth of

the speculum, or by means of a strong light reflected by a head mirror.

The view of the bladder obtained in this way is a direct one; and the open speculum allows the operator to touch any part of the bladder with a sound, and to introduce various instruments with ease.

Instruments.—The necessary instruments are: a strong light, a head mirror, vesical specula with obturators, a urethral calibrator and dilator, an evacuator for removing urine, an ureteral searcher, and a pair of long mouse-toothed forceps.

In emergency cases a candle for light, a head mirror, a rubber catheter, and a rubber or glass pea syringe for evacuating urine, with a No. 6, 8, or 10 cylindrical speculum, are all the instruments actually needed.

The most convenient light is a mignon electric lamp, attached to a flexible steel head band, the lamp being fastened to the band by a double ball-valve joint. The current is furnished by a small storage battery.

The writer has derived the most satisfactory results from the use of an acetylene gas bicycle lamp, which emits a beautiful white light, is easily handled, and is convenient for carrying about. To concentrate the rays, the lens must be reversed.

Specula. — Kelly's vesical specula (Fig. 485, 1, and Fig. 486) are simple cylinders, 8 cm. (three and one-fifth inches) long, and of equal diameter throughout; made of German silver, and nickel-plated. There is a funnel-shaped expansion at the outer end of the speculum 15 mm. long, inclined at an angle of sixty degrees to the cylinder. The vesical end of the speculum must be rounded in toward its lumen, and under no circumstances must a ragged or knife edge be left to cut the mucosa.

Each instrument has its obturator, which is to be used only for the purpose of rounding out the end of the speculum during introduction. To facilitate the introduction of the cystoscope there must be no shoulder between the end of the speculum and its obturator, to injure the urethra.

Specula are made in numbers ranging from 5 to 20, each number representing the diameter of the cylinder in millimetres; the sizes below No. 12 are used for examinations and those above to secure a wide lumen in operations upon the bladder.

For the purpose of giving a maximum area of inspection and to facilitate treatment, especially in using instruments with crossed blades, Kelly has recently (Johns Hopkins Bulletin, 1900, xi., p. 93) presented a new model of his speculum (Fig. 486).

The *dilator* (Fig. 485, No. 2) is a conical instrument 7 cm. (three inches) long, with a blunt point 3 mm. in diameter, widening out to 16 mm. at its base. This one simple conical dilator, representing an infinite series on its sides, takes the place of the interrupted series of the Hegar dilators commonly used, as the external orifice is the only part of the urethra which needs stretching to admit the

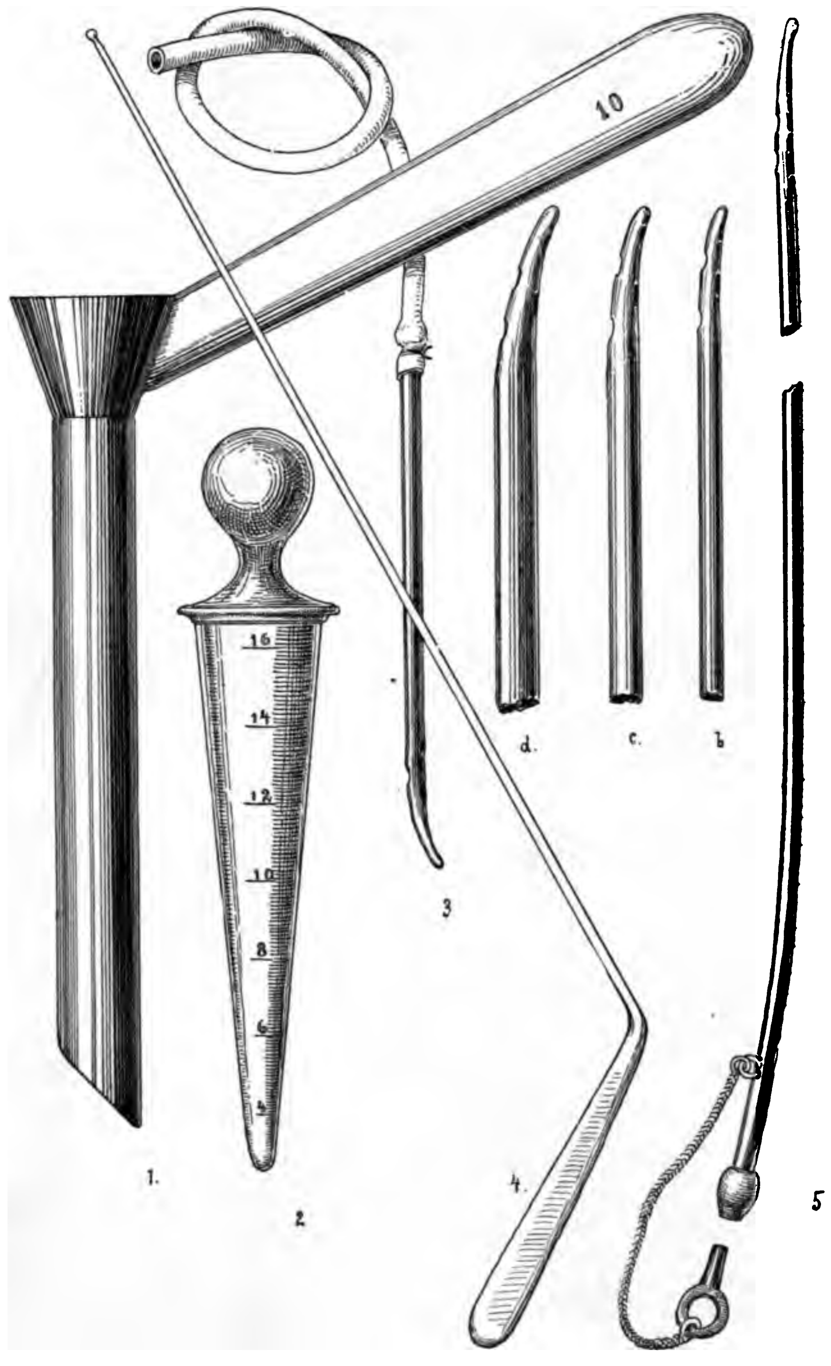

FIG. 485.—1, Bevelled cystoscope; 2, urethral calibrator and dilator; 3, short metal ureteral catheter; 4, searcher for locating ureteral orifice; 5, *a*, *b*, *c*, *d*, long metal ureteral catheters.

specula commonly used. The rest of the canal is so elastic that it yields at once to the obturator and opens up to the full size of the speculum without previous dilatation and without undergoing any injury.

The *evacuator* (Fig. 488) is used to empty the bladder

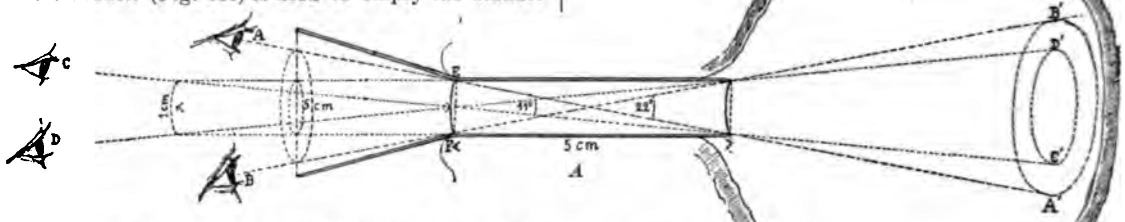
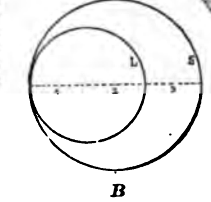

FIG. 486.—*A* Shows the Simple Cylindrical Speculum Compared with a Short Speculum with a Large Funnel-Shaped Vulvar End. The bladder is seen in horizontal section, and the distance of the posterior wall from the internal urethral orifice is 5.7 cm., the average distance shown by Hunner and Lyon's measurements of air-distended bladders made in my clinic. While the eye at C and D is able to view only a circle of the size of D′ and C′ in the posterior bladder wall, through the larger speculum the eye at A and B is able to view the circle A′ and B′. The angle subtended by the smaller circle is 11°, as contrasted with 22° in the case of the larger circle. *B* Shows, projected from a flat surface, how much greater is the area seen through the shorter speculum with the large funnel-shaped orifice. The ratio in the diameters of the circles is as 2 to 3.

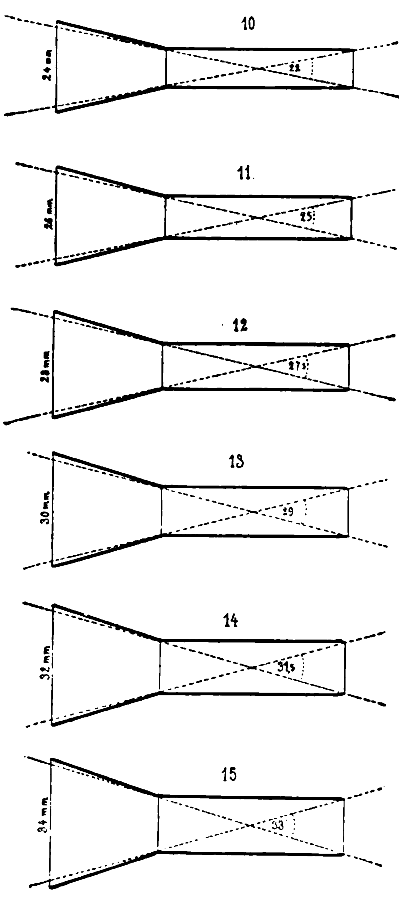

FIG. 487.—Shows a Series of Specula (half natural size) constructed with tubes varying from 9 up to 15 mm. in diameter, with the conical vulvar ends increasing in like ratio in accordance with the angle made by two lines intersecting in the centre of the tube. These angles are respectively 21°, 22°, 25°, 27.5°, 29°, 31.5°, 33°. The cone is made 2 mm. wider than the prolongation of the intersecting lines; that is to say, the orifices are respectively 21, 24, 26, 28, 30, 32, 34 mm. in width.

of residual urine which the patient often cannot expel, and which cannot be removed by a catheter. It must also be used from time to time to remove the urine accumulating during a prolonged examination. Kelly's evacuator is a small hollow perforated ball connected by fine rubber tubing, about 35 cm. (fourteen inches) long, with a rubber exhausting bulb. The rubber tube is cut about 5 cm. from the ball, and a piece of glass tubing inserted which serves both as a telltale to show when the urine is flowing in the tube, and as a means of giving rigidity to the tube when it is picked up for introduction into the bladder.

If the patient lies on the back during cystoscopic examination, the evacuator must be used much oftener, as a small quantity of urine easily obscures the field of view in this posture. In the knee-breast position, on the other hand, a little clear urine in a pool in the inverted vault of the bladder in no way interferes with a thorough inspection.

The assistant compresses the bulb, thereby expelling the air, while the examiner drops the little perforated ball into the pool of urine. When the assistant relaxes the pressure on the bulb, it expands and sucks up the urine. The evacuation will be more rapid if the bulb is held well below the level of the bladder. If there is

FIG. 488.—The Evacuator.

only a little urine to be taken up, it will escape faster by occasionally withdrawing the ball a little, so as to suck up some air with the urine.

The long mouse-tooth forceps (Fig. 489) is a light instrument 24 cm. (nine inches) long, with slender arms 10.5 cm. (about four inches) long, and at the ends delicate, slightly recurved mouse teeth.

The urethral searcher (Fig. 485, 4) is a small rod 18 cm. (seven inches) long with a little bulbous end (3×1.5 mm.) and a handle 6 cm. (2.5 inches) long set at an angle of 120 degrees. It is used in touching any part of the bladder wall, in exploring a sinus, and particularly in locating the ureteral orifices in doubtful cases.

FIG. 489.—The Long Mouse-Tooth Forceps.

The Applicator.—Any piece of flexible wire about 15 cm. long will do as an applicator to carry medicated cotton to all points on the bladder or the urethra.

Other useful instruments are a speculum graduated in centimetres for measuring the distance between points on the bladder wall (the external or internal urethral orifices) and a flattened searcher, likewise graduated in centimetres and half centimetres.

FIG. 490.—Patient in the Dorsal Posture.

THE TECHNIQUE OF CYSTOSCOPIC EXAMINATION.—*Asepsis.*—Asepsis must be maintained throughout every examination by handling only aseptic (boiled) instruments, introduced by (surgically) clean hands, through a cleansed urethral orifice. All instruments must have been boiled and be placed upon a sterile towel. Wipe the urethral orifice with a piece of sterile gauze, removing any leucorrheal or other discharges. The hands must be scrubbed surgically clean, and as far as possible the utmost precaution must be taken to avoid touching any part of the instruments but the handles. If this were always done, no infection could ever occur even with infected hands. Every instrument should be constantly inspected to detect any rough or scaling surface liable to cut the mucous membrane.

Preparation of the Patient.—Be sure that the bowel has been recently emptied, that the urine has been passed immediately before coming to the table, and that some time has elapsed since the patient has taken her last meal.

Anæsthesia.—"A general anæsthetic is needed only for a nervous woman. Local anæsthesia by means of a ten-per-cent. solution of cocaine, applied on a pledget of cotton wound on a metal rod and introduced just within the external urethral orifice for five minutes beforehand, is sufficient to benumb sensation so entirely that any required

FIG. 491.—Examining Patient in the Dorsal Posture.

FIG. 492.—Vesical Speculum Introduced with the Patient in the Knee-Breast Posture.

dilatation may be made and the speculum introduced without much discomfort" (Kelly).

Posture of the Patient.—"Two postures are available, an elevated dorsal and a knee-breast. The dorsal position (Figs. 490 and 491) is the most convenient to use and the least tiring to the patient, but it is only of service in thin patients, and the atmospheric expansion is not so good; the bladder of a fat woman will rarely distend at all in this posture. The head and thorax rest on the table, while the pelvis is raised by putting one or two bran cushions under the buttocks, so as to elevate them 20 or 30 cm. (eight or twelve inches) or more above the table level. This gives a pitch to the pelvic and lower abdominal viscera which makes them gravitate toward the diaphragm, and as soon as a speculum is introduced the bladder sucks in air enough to distend it.

"When the bladder does not expand, and yet it is particularly desirable to use the dorsal position on account of the inability of the patient to stand the inconvenience and fatigue of the knee-breast position, the bladder may be distended and the pelvis relieved of the small intestines by first placing her in the knee-breast position for a minute and letting in air with a catheter; she is then turned on her back with hips elevated on the cushions, taking care to keep the pelvis all the time well above the level of the abdomen. The speculum may now be introduced and a satisfactory examination made. A bladder distended in this way will often remain well distended until the hips are let down again to the table level.

"*The knee-breast position* (Fig. 492) is the one position most satisfactory and applicable in all cases. The patient kneels with her knees separated ten or twelve inches, close to the end of the table, and, keeping the buttocks as high as possible, lets the back curve in, and brings the side of the face down on the table. If she squats a little, dropping the buttocks slightly toward her feet, she will be more conveniently disposed for the examination. Sometimes, to get a good expansion, it is necessary to push the thighs in the opposite direction beyond the vertical. If she is under an anæsthetic, the best way to hold her in the knee-breast position is for two assistants to stand, one on each side, close up to the body to prevent it from falling sidewise, each grasping the body with one arm thrown over the back, and holding the leg in the crotch of the knee with the other hand to keep it from slipping up or down" (Kelly).

An apparatus like that shown in the text (Fig. 493), and devised by Dr. G. B. Miller, is useful where assistants are scarce, but the thigh bands must not be allowed to cut into the femoral fold.

Calibrating and Dilating the Urethral Orifice.—"Before dilating the urethra and introducing the speculum it is well to calibrate it, that is, to measure its diameter in millimetres as a guide to the amount of dilatation needed to admit a speculum; for example, if the urethral orifice has a diameter of 6 or 7 mm. only, it cannot be dilated up to 10 or 12 mm. without a slight rupture of its margins; calibration in this case would induce one to use a speculum a size or two smaller than usual. Again, the calibration often shows that the orifice is already so large that it needs no preliminary dilatation. A practised eye will usually be able to gauge the size of the urethral orifice at once, and to select the exact size of speculum suitable for introduction.

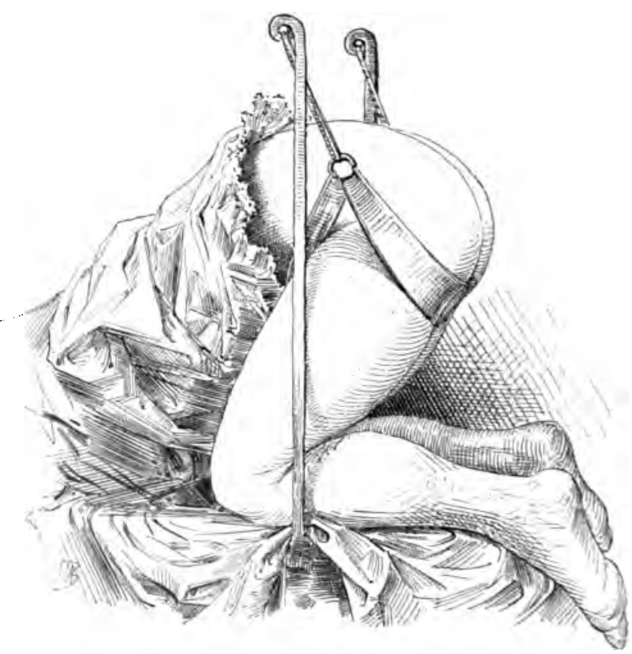

FIG. 493.—Patient in a Harness in the Knee-Breast Position for Cystoscopic Examination.

"To calibrate the orifice, the small end of the conical dilator (Fig. 485, 2) is pushed into the urethra until it fits snugly, when the index finger marks the point in contact with the urethral orifice; the dilator is then withdrawn and the diameter in millimetres read off. If it is 9 or 10, the speculum of the same number is taken up and introduced without dilatation; if the number indicating the diameter is 7 or 8, the urethra must first be dilated up to the size of the speculum to be used.

FIG. 494.—Holding the Vesical Speculum Ready for Introduction. The thumb presses the obturator firmly in.

"Boroglyceride forms *the best lubricant* for dilator and speculum because it is colorless. Vaseline sometimes leaves a film behind which looks like pus.

"*To dilate the orifice*, the dilator, which is one and the same instrument with the calibrator, is introduced into the urethra in the direction of its axis, with a slight boring motion, until the required distention is reached in a few seconds. Often there is no injury at all from such a dilatation, while at other times one or two shallow ruptures, 1 mm. deep and from 3 to 5 mm. long, are made at the posterior margin. I have never seen any serious bleeding nor have I had to treat the ruptures later as fissures; only two or three times have I had to put in a fine suture to stop the oozing. An unusually small and rigid orifice should be cut posteriorly, as suggested by Simon; then, after the examination, the cut is closed with one or two fine silk sutures" (Kelly).

Introducing the Speculum.—"A skilful examiner will select a suitable speculum, No. 7, 8, 9, or 10, or one of the half sizes between, according to the case, the age of the patient, or the purpose of the examination; a patient with a sensitive urethra may often be treated with less discomfort and with equal facility through a No. 7½ or 8 speculum. The smaller sizes are better adapted to girls and to young women with small urethræ. Beginners in cystoscopy are apt to select a larger speculum, using a No. 10 or 11; with experience they will drop a size or two.

"To introduce the speculum, it is grasped as shown in Fig. 494 and the obturator is kept from slipping back into the cylinder by a decided pressure with the thumb, continued until the end has entered into the bladder. The urethra, wiped clean with boric acid solution, is exposed by an assistant holding the buttocks and the labia well apart, while the point of the speculum, coated with the boroglyceride solution, is applied to the urethral orifice, and pushed through the urethra into the bladder with a gentle sweep around the pubic arch. The handle of the speculum is now firmly grasped, while the obturator is withdrawn with a slight rotary motion. If the internal urethral orifice is drawn well into the pelvis by the posture, the urethra is so much curved that there is danger of injuring it by pushing the speculum hard against its posterior wall; this must be avoided by introducing the speculum in a decided curve. The moment the obturator is taken out the air rushes in and the bladder is dilated and ready for the inspection.

"If the bladder does not expand in this way the examiner will usually find that the patient has assumed a faulty position, and as soon as this is corrected the expansion occurs.

"*Viewing the Bladder.*—It takes far less time to view the whole interior of the bladder than it does to describe the method of inspection (Fig. 495); indeed, after practice, a few seconds will be sufficient to determine by actual sight whether any portion of the interior is sound or diseased.

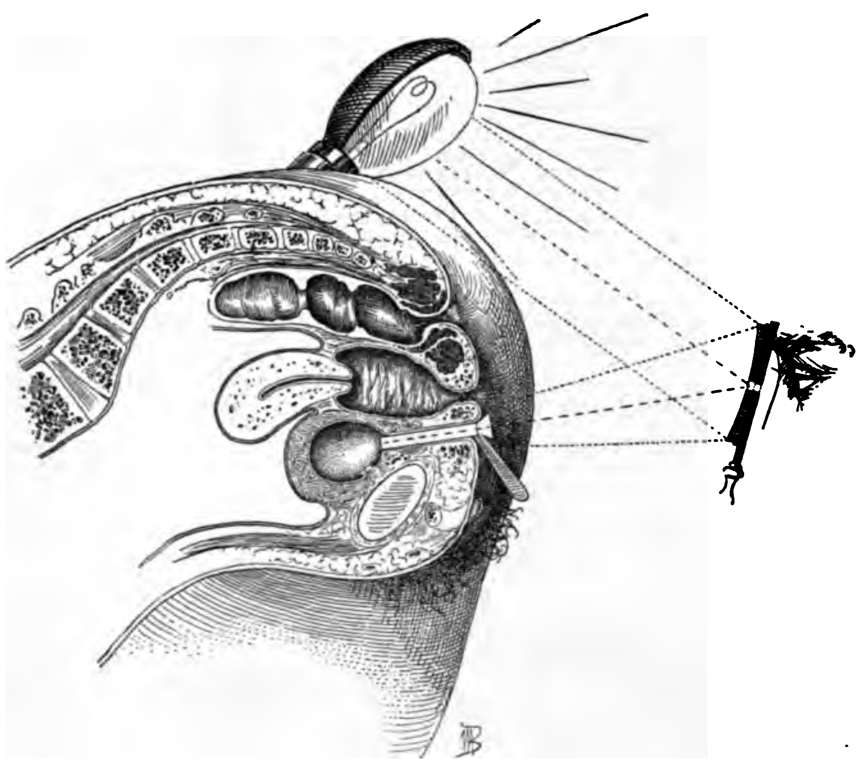

FIG. 495.—Examination of the Bladder with the Patient in the Knee-Breast Position.

"If the patient is in the knee-breast position the examiner sits on a stool with his eyes a little below the level of the urethra, grasping the handle of the speculum,

which is turned upward, and he should wear the head mirror over the same eye he uses at the microscope.

"The assistant now holds the electric droplight close to the end of the sacrum, which is protected from the heat by one or two towels, and the lower margin of the head mirror is drawn away from the face and turned until the reflected light spot falls within the bladder. Men accustomed to throat and eye work will find no difficulty in putting a good illumination at once just where they want it, while to the inexperienced man the apparent waywardness of the light will be his chief trouble throughout. The direct ray of the little electric headlight makes the illumination of the field an easier task.

"The inspection of the bladder naturally begins with the posterior hemisphere about the posterior pole, opposite the internal urethral orifice, from 3 to 5 cm. distant from the anterior wall, but not more than 2 or 3 cm. from the end of the speculum, which is pushed well into the bladder.

"The whole posterior hemisphere is first examined as the end of the instrument is directed to the right and to the left, by alternately raising and dropping the handle so that every part of the mucosa is passed in review at least twice.

"*The normal background of the inflated bladder* seen in this way is a dull white, with here and there large vessels branching and anastomosing over it in an irregular manner. The fine rosy capillary injection seen in a contracted bladder is not visible when it is distended with air, for the minuter vessels are emptied, both by the expansion and by the posture of the patient. At a point 1 or 2 cm. above the posterior pole a rounded red spot of capillary injection is often seen, which may easily be mistaken for a localized inflammation, but which is merely a suction hyperæmia induced at this point by contact with the end of the speculum during the withdrawal of the obturator.

"The larger blood-vessels spring out of the submucosa where they are first seen in a hazy way, becoming clearer and with sharply defined outlines on the surface, where they divide and subdivide into numerous branches. Occasionally an artery is seen pulsating, and a large dark vein may sometimes be seen gradually disappearing from view as it penetrates the walls obliquely. The mucous surface on the right and the left of the posterior hemisphere is often divided up by shallow interlacing ridges, or again a sharp ridge 2 to 3 cm. long is seen to cross the field obliquely; these ridges are formed by the inner muscular bundles irregularly arranged. Numerous little glistening points are due to moisture on slight inequalities of surface which catch and reflect the light.

"By dropping the handle of the speculum decidedly, its inner end is raised and the vault or summit of the bladder is brought into view, and every part of the organ inspected by moving the end from side to side. By elevating the handle decidedly, the floor of the bladder is examined in the same way, and then by moving it to the left and to the right, the right and left walls come into view.

"The only parts which remain unexamined are those contiguous to the internal urethral orifice, and these are now seen by a still more decided elevation and depression of the handle. With a marked depression of the speculum the vesical triangle comes into view, always a little more injected than the rest of the bladder, due to the fact that the mucosa and the underlying tissues are intimately connected, which prevents this part from expanding and becoming anæmic like the rest of the bladder.

"Turning the speculum from fifteen to twenty degrees—generally the latter—to the right or to the left a little pinkish prominence is seen—the *mons ureteris*—which marks the position of the urethral orifice; this usually looks like a fine transverse line about 2 mm. long on the side of the mons. It is sometimes a faint streak, like a little water line on paper. At other times the orifice appears as a little pit or a mere point. In some young nulliparous women, the ureteral opening is indicated by a small round black point which has not been observed in older women who had borne children (Hunner and Lyon). Immediately around the ureteral orifice is a paler area about 1 mm. broad, and surrounding this a rosy area 3 or 4 mm. broad. I have several times seen a blood-vessel emerging out of it on to the vesical mucosa. If a V with its angle at thirty degrees is marked on the cylinder of the speculum, near the handle, by bringing one of the arms of the V parallel to the axis of the urethra the other arm will then point toward one of the ureteral orifices, which may now be found at once on looking through the speculum.

"If the ureteral orifice is watched for half a minute or so a little clear urine will be seen to spout out from the surface, forming a jet which lasts two or three seconds, to be repeated again in the course of a minute.

"Sometimes the urine spurts up free from the surface of the bladder, shoots into the lumen of the speculum and trickles down to the outer edge. By holding the end of the speculum close up under the ureter, or by using the oblique speculum adapted specially to this purpose, (Fig. 485, 1) enough urine can be caught up with pledgets of cotton or in a small graduate to answer the purpose of a physical, chemical, and microscopic examination. When the bladder is inflamed or ulcerated, it is sometimes of great advantage to get a little urine from one or both sides in this way, because it avoids the risk of a possible infection of a ureter by putting in a catheter.

"The inter-ureteric line is often distinctly seen from its having a little deeper color than the bladder behind it, or from a slight elevation.

"In the process of the examination of the entire bladder, conducted in this way, the field of vision has changed from the posterior wall perpendicular to the plane of vision to the triangular area which lies almost parallel to it; at right angles differences in color are best seen, while in the plane of vision outlines which cross it come out more distinctly.

"The retrosymphyseal area comes into view on elevating the handle of the speculum so as to direct the inner end toward the symphysis pubis.

"Occasionally a bladder will be found which does not remain ballooned out with air, but undergoes periods of more or less rhythmic contraction, each of which lasts half a minute or more. With the contraction there is an influx of blood into the capillaries, and the mucous membrane assumes a rosy hue, becoming more intense as the contraction increases, until the whole organ is thrown into small folds like a labyrinth of cerebral convolutions. With the contraction the air is audibly expelled and often urine comes sputtering out with it. After waiting from half a minute to a minute the contraction relaxes and the bladder expands, and the examination can be continued. The color and appearance of the walls and of the vessels of a normal bladder must be well fixed in the mind by numerous examinations, because the normal conditions are the standards of comparison in determining the presence of areas of congestion, inflammation, or other diseases.

"Insufficient expansion of the bladder will be noticed in advanced pregnancy, or in the case of a tumor blocking the pelvis, or in ascites. It may also be due to the fact that the patient in taking the knee-breast posture arches her back, and raises her chest too high from the table, and so interferes with the action of gravity on the intestines. Often, too, a little time must be allowed for the viscera to gravitate slowly toward the diaphragm, and so create the necessary suction for the distention of the bladder.

"Too great an expansion of the bladder may also be troublesome. The difficulty is that the trigonum and the ureteral orifices are then lifted up so high that the examiner has to bring his head so far under the patient that his position is extremely awkward and he does not get enough light for inspection. This may be remedied in several ways:

"(*a*) Before introducing the cystoscope a speculum is always put into the vagina, which then balloons out with air and lets its anterior wall with the floor of the bladder drop in the direction of the symphysis; then when the

vesical speculum is introduced the available expansion space of the pelvis, already partly occupied by the distended vagina, is so diminished that the floor of the bladder remains more nearly in the plane of vision. In parous women the atmospheric expansion of the vagina is usually spontaneous. Distention of the rectum with air will sometimes produce the same effect.

"(b) By putting a cotton pack in the vagina or by depressing its anterior wall with a spatula, any particular portion of the base of the bladder can held down in view.

"(c) Cases where there is a tendency to an excessive expansion may, as a rule, be easily examined in the dorsal posture, when it is naturally not so great.

"The presence of air in the bladder is rarely painful so long as the urethra is open and the air enters and escapes freely with each respiratory movement. But not infrequently as soon as the speculum is taken out the patient feels a cramping pain, which is not relieved until she has been able to seat herself on a vessel to expel the air. To avoid this after-pain, the examiner may leave the speculum in place, or slip a catheter in, and then lower the patient gently from the knee-breast posture on to her side, so as to let the air out gradually.

"It is not necessary to take any special precaution after a vesical examination, unless it has been prolonged enough to weary the patient, or unless she is feeble or nervous; under these circumstances rest for an hour or two, with a half teaspoonful of aromatic spirits of ammonia, may be prescribed.

"The field of usefulness of the cystoscopic method just described is a large one, commensurate with the entire field of vesical disease, and the practitioner who uses it liberally will be rewarded by constantly discovering that affections hitherto described as merely functional have definite local lesions as their basis, and are often speedily amenable to simple methods of treatment.

"I wish further to insist that a cystoscopic examination should be made in every case where a vesical affection is more than transient and the diagnosis is not absolutely clear without it, and that every part of the bladder should then be thoroughly inspected" (Kelly).

Mensuration of the Female Bladder.

G. L. Hunner and I. P. Lyon have recently published (*Journ. Am. Med. Assn.*, 1899, vol. xxxiii., p. 1515) some very interesting and instructive results of their work on bladder capacity, "undertaken primarily to afford to the gynecologist some additional information on the size, shape, position, internal mensuration, and capacity of the bladder, and incidentally to furnish the anatomist with some of the same data."

"1. All measurements were made on living women with the bladder perfectly healthy—most cases—or so slightly disturbed from the normal as not to affect the accuracy of the results. 2. All examinations were made with the women in the knee-breast posture, with the rectum, vagina, and bladder all—with a few exceptions —dilated by atmospheric pressure, produced by simply opening these cavities to the outside air by the insertion of a speculum, by the methods so well known from the writings of Kelly. . . .

"It was found that by this method of dilatation no discomfort was felt by the woman, and consequently no resistance, either voluntary or involuntary, was offered by her, thus adding to the uniformity of the observations. On the contrary, it was found that distention by fluid to discomfort was subject to the peculiar and varying irritability or tolerance of the subject, and thus gave no uniform basis of comparison. . . .

"The woman was put in the knee-breast posture and the three pelvic cavities were each allowed to dilate by natural atmospheric pressure. A closely fitting catheter was then introduced into the bladder, attached at its external end to a long soft-rubber tube. The tube was then closed by a clamp, and the woman then rotated carefully by assistants from the knee-breast into the dorsal position. The rubber was then introduced into a deep vessel of water and from below upward into an inverted glass, graduated cylinder completely filled with water, and was held pointing upward in this position by an assistant. The clamp on the tube was then released, and the entire content of the bladder was then expressed by the ordinary gynecological bimanual method, with one hand exerting pressure on the bladder externally from the abdominal wall and the other pressing at the same time on the bladder from within the vagina or rectum. . . .

"The air thus expressed was gathered in the glass cylinder, displacing from above down an equal amount of water, and the amount read off on the graduated cylinder, thus determining the exact air capacity of the bladder. . . .

"In the 25 women examined, the average bladder capacity by atmospheric distention was found to be 303 c.c., individual cases ranging from a minimum of 160 to a maximum of 545 c.c. . . . The capacity in general follows the general size of the bladder by internal mensuration, and also in a general way the size of the woman. Measurement was also made, in 22 cases, of the fluid contents of the bladder, boric solution being used for the purpose. On anæsthetized patients the solution was introduced through the double-barrelled catheter until it overflowed through the upper barrel; on those without anæsthesia, until discomfort was caused to the woman. The average fluid capacity was thus found to be 429.7 c.c., varying in individual cases from a minimum of 210 to a maximum of 840 c.c. The average fluid capacity of the bladder was thus found to be more than one-third greater than the air capacity, a difference that would be expected because of the elasticity of the bladder walls under increased pressure.

"With reference to the influence of anæsthesia on the capacity, it was shown that the average capacity of the bladder is somewhat greater than without anæsthesia, explained, doubtless, by the relaxation of the bladder during anæsthesia."

Instrumental Mensuration.—"The second chief object of study was to gather some statistics on the internal mensuration of the bladder under atmospheric dilatation in the knee-breast posture. The importance of such measurements to the gynecologist is apparent, but they have never before been accurately ascertained."

The distance of certain points from the internal urethral orifice was measured. "The points chosen were: 1. The *vertex*, or summit, the most prominent and distant point in the concavity of the upward and anterior bulging of the ventral wall, usually placed well above the reflexion of the peritoneum and the departure of the urachus. 2. The most prominent and distant point in the upward and dorsal bulging of the *posterior wall.* This point is found a few centimetres above the peritoneal reflexion, and is usually opposite the end of the cystoscope when held in the axis of the patient's body. Quite frequently, however, the cystoscope must be directed more posteriorly to bring this point into view. 3. The point of the greatest outward bulging in the *left lateral wall.* 4. The point of greatest outward bulging in the *right lateral wall*. . . .

"The average measurements obtained for these four points were: to summit, 7.14 cm.; to posterior wall, 5.77 cm.; to left lateral wall, 6.70 cm.; to right lateral wall, 5.92 cm. . . .

"The *asymmetry* of the dilated bladder, shown by the unequal lateral measurements, is of interest. In 16 cases the left lateral measurement is greater than the right; the reverse is true in 6, and in 3 the left and right internal measurements are equal. The occasional asymmetric position of the bladder has been noticed by anatomists, but never before has this asymmetry been recorded in so large a proportion of cases. This tendency of the bladder to be placed more to the left than to the right, at least when the patient is in the knee-breast posture with the pelvic cavities dilated with air, may be explained by the fact that the rectum in women is found much more commonly on the right than the left within the pelvis, and thus the distended rectum tends to displace the blad-

der toward the left. Our observations on the position of the rectum in women are directly opposed to the usual statements of text-books of anatomy and surgery. . . .

"Another factor producing some slight asymmetry of the dilated bladder is the fact that the uterus is usually placed somewhat to the left of the median line and encroaches on the left upper posterior quadrant of the bladder. The influence of this factor is to lower the point of greatest outward bulging of the left lateral wall so that it is found to be on a lower level than on the right lateral wall. . . .

"With the patient in the knee-breast posture, and the rectum, vagina, and bladder all dilated by atmospheric pressure, it was found that the true pelvis was always completely occupied by these organs, and that the bladder and uterus tended to rise upward and forward. In multiparæ the uterus was found to be displaced so far upward and forward that its fundus could be felt within a few centimetres of the umbilicus.

"The ballooning of the rectum and vagina before the bladder was allowed to fill with air was found to be of great importance to the ease of examining the ureteral orifices, in the fact that the dilated rectum and vagina press from behind upon the base of the bladder, thus bringing the trigonum and ureteral orifices forward and into easy view of the speculum. Neglect of this point and failure to first allow the rectum and vagina to dilate is accountable in large measure for the difficulty found by so many gynecologists in catheterizing the ureters. . . .

"The bladder, as a whole, when dilated with air and observed *during operation within the pelvic cavity*—from abdominal section—was found to be ellipsoidal in form, flattened somewhat in its antero-posterior diameter and increased transversely. The transverse diameter was always the greatest measurement. Mathematical calculation of the cubic content of an ellipsoidal viscus of the dimensions of the bladder corresponded closely with actual air capacity obtained by expression" (Hunner and Lyon).

Abnormal Urine; Examination of the Urine.

Color.—The color of the urine in diseases of the bladder may vary from the almost colorless urine of hysteria to the reddish-black urine of hæmoglobinuria or of hemorrhage from the urinary tract. It may be of a pale yellow color, or opaque from admixture of pus.

The *odor* of cystic urine is usually ammoniacal, unless the reaction is very acid.

The *reaction* of the urine in cystitis, when due to the presence of the coli communis, streptococcus, tubercle, or typhoid bacillus in pure culture, is acid; but when caused by saprophytes, pyogenic bacteria, or both, with decomposition of urea, its reaction is alkaline.

Specific gravity in vesical disease is usually about 1.010–1.015, but responds to all the usual features which induce variations in the quantity of the urine.

Mucus.—Mucus in the urine is rarely of diagnostic import, being always increased in any vesical inflammation.

Epithelium.—Exfoliation of epithelium always takes place in cystitis, and microscopically we can determine from what layer of the mucous membrane it is derived and to what extent the vesical wall is involved. The superficial cells are large, round, or rectangular pavement cells; those from the deeper layers, caudate or spindle-shaped. The latter varieties resemble cells from the ureter. The deep vesical cells may be confounded with cells given off from the deeper layers of the pelvis of the kidney, though these are usually somewhat smaller in size and lighter in structure than the deep bladder cells.

Blood and Albumin.—Hæmaturia may be due to hemorrhage from any portion of the urinary tract. In acid urine the red corpuscles present a shrivelled, crenated appearance; in faintly acid, diluted urine the corpuscles are quite full from endosmosis. Hæmaturia accompanies acute congestion and varicose veins. From the free surface of the bladder the blood escapes either in a free state or in small clots. Such hemorrhages imply the presence of a calculus or a foreign body, or of some form of new growth, in the bladder. But they may also occur in connection with an ulcerated condition of the vesical mucous membrane or as a result of malaria. When the blood comes from the kidneys it is intimately intermingled with the urine.

From a study of nineteen cases of hæmaturia, David Newman (*Lancet*, July 2, 9, and 16, 1898) concludes that "the source of the hemorrhage is often determined by studying the character of the urine, or of the blood clot if such is present. The farther down the source of the hemorrhage, as a rule, the less is the alteration of the appearance of the blood; though this is not true when the hemorrhage has been from the bladder in cases in which there is residual urine, as the color is rapidly changed in such instances. Occasionally the clot encloses some of the tissue from the source of the hemorrhage, and then microscopic examination makes practically an absolute diagnosis. If clots are large, they cannot have come from high up near the kidneys. Renal hæmaturia is apt to appear very suddenly, and disappear quite as suddenly. In case of stone in any location, rest causes improvement, and exercise increases the trouble. The cystoscope often gives aid. The estimation of the quantity of hæmoglobin and comparison with the amount of albumin in the urine will tell whether the albumin present is due entirely to the blood or if there is also albuminuria. If there is excess of albumin, this indicates a probable renal source of the hemorrhage. Hemorrhage from renal calculus is usually slight, appears at somewhat long intervals, and is increased by exercise. Bleeding from renal tumors is profuse, is apt to be more continuous, and is very likely to come on while the patient is recumbent. Tuberculous disease causes hemorrhage which often occurs at long intervals, is of slight severity, and not usually increased by exercise; and the quantity of albumin is in excess of that attributable to the blood present. Hæmaturia may also be due to passive hyperæmia, or may follow reflex inhibition of the renal functions, due to some acute abdominal affection acting upon the solar plexus. Cases of hæmaturia are becoming more and more the subjects of surgical treatment."

Discussing the diagnostic differences between pyelitis and cystitis, G. Rosenfeld (*Berliner klin. Woch.*, October 4, 1898) notes that an alkaline reaction is not found in uncomplicated pyelitis; in cystitis, even of severe grade, the albumin in the urine does not amount to more than 0.1 per cent., this being the most characteristic point of differentiation, for in pyelitis it is often as much as three times greater than this; if most of the pus corpuscles present are crenated, the condition is probably pyelitis, which is also true in case the red corpuscles are decomposed; if any hemorrhage occurs, it is but slight.

Bits of tissue teased in glycerin and examined microscopically will sometimes lead to the diagnosis of a vesical tumor or an ulcer; pieces of cast-off membrane will indicate an exudative or exfoliative inflammation of the walls of the bladder; and débris removed from ulcers often contain tubercle bacilli and confirm the diagnosis of an invasion of those microbes as the cause of the cystitis.

It is advisable in many cases to excise a piece from a new growth and submit it to microscopical examination, in order to determine the exact nature of the growth and the best method for its removal.

Pyuria.—Pus in the urine may be derived from the vagina, urethra, bladder, kidneys or ureters, or its presence may be due to a rupture of a pyosalpinx or of an appendiceal abscess into the bladder. Urine retained within a patent urachus, a duplicate or sacculate bladder, a cystocele, or an urethrocele undergoes fermentative changes and shows the presence of pus corpuscles. When they are present in large quantity, the urine presents a gruel-like appearance; when in moderate quantity, a fresh-cider-like opalescence. In recent acute infection the pus is in proportion to the intensity of the inflammation; in old cases the urine is loaded with bacteria, but contains little pus.

Parasites.—The filaria sanguinis hominis is occasion-

ally found in the bladder and induces chyluria. The urine presents a creamy appearance to the naked eye and under the microscope. The period of the parasite's activity is at night, the morning urine being milky, while that voided during the day is quite clear.

The heads and hooklets of the echinococcus have been seen in the urine; ulcerative action in the kidney or in a prevesical tumor having set them free.

Treatment of Cystitis.

Prophylaxis.—The prevention of inflammatory disease of the bladder involves the early recognition of urethral disorders, and the immediate employment of appropriate treatment. If any vesical, pelvic, rectal, ureteral, or renal disease which renders the bladder liable to infection is present, this should be relieved; and the injunction to observe the strictest surgical asepsis in all manipulations about the bladder cannot be given too often.

Treatment of Acute Cystitis.—During the acute stage active local interference is contraindicated; and the demands of the patient will direct our attention to the relief of pain, and to the restoration of the power completely to empty the bladder. To stimulate vesical contraction, apply heat or cold over the suprapubic region; failing these a sterile catheter must be introduced and the bladder emptied. The intense pain due to vesical irritability and tenesmus must be relieved by morphine, administered either by the mouth or by suppository. At the same time enough bromide and chloral should be given to insure ample sleep. Hot poultices, or in some cases an ice bag over the bladder, affords considerable comfort; continuous rectal, not vaginal, irrigation of ice water through a Kemp double-current tube exerts an almost marvellous effect.

The Care of the Patient.—Absolute rest in bed; a strictly fluid diet of milk or milk preparations, with Vichy; active purgation by Hunyadi, Rubinat, or other salines, and oleum ricini at night to insure complete emptying of the intestinal tract—such are some of the simple measures which should be employed. From our study of the urine we learn what drugs to administer, correcting alkalinity by the use of sodium benzoate and boric acid, āā gr. v. to x. *ter in die;* or, in case the urine is excessively acid, we may prescribe the acetate, bicarbonate, and citrate of potassium, āā gr. v. to x., with ext. pichi fl., ♏ xxx. to xl., every three hours, in a liberal quantity of water. For their supposed antiseptic action on the urine, salol and urotropin are highly recommended. When there is painful, frequent urination, if the bladder is capable of emptying itself, Morton recommends instillations of twenty minims of a one or two per-cent. silver nitrate solution, repeated every second or third day. The bladder must be completely emptied before the injection is made.

The treatment of chronic cystitis depends upon the nature of the infecting organism, the character of the urine, the condition of the bladder walls, the nature of the predisposing cause, whether calculus, neoplasm, foreign body, etc. So far as general measures are concerned it is necessary to insist upon the following: Rest in bed, a light diet, the avoidance of condiments and of sweet and alcoholic drinks; regular, periodic, complete evacuation of the bladder; free movement of the bowels through the use of salines; moderate exercise; the avoidance of over-heating, and abstention from intercourse; the daily use of hot and cold baths, or of sitz baths; and, finally, seven or eight hours of refreshing sleep. In other words, everything should be done to bring the patient's general condition up to the highest point.

The treatment of the interior of the bladder is accomplished in several ways: by internal medication; by injections into the bladder; by direct applications; and by surgical procedures.

1. Certain drugs may be used, such as sodium benzoate or boric acid, to render the urine acid; others for the purpose of diminishing the growth of micro-organisms in the bladder, notably salol and salicylate of sodium in full doses, and quinine in moderate amount. Urotropin, gr. xxx. per diem, has been recommended by Morton for dissolving phosphatic concretions.

2. Injections into the bladder are used in four ways, viz.:

(*a*) Washing out the bladder after the manner of Kelly, by attaching a glass catheter and a glass funnel to either end of a piece of rubber tubing three or four feet long, and pouring the solution into the funnel, the rapidity of the inflow being in proportion to the height at which the funnel is held. The bladder is filled to the point of tolerance, when on lowering the funnel the vesical contents will run out. This plan of irrigating the bladder has the advantage of safety in that overdistention is not likely to be produced, for the bladder will contract and expel its contents through the funnel, unless it be held too high.

The same method of making injections may be employed when we desire to treat the entire mucous membrane of a bladder which contains pus, mucus, and non-coagulated blood—that is, one in which there is a condition of mixed infection. For this purpose weak solutions of potassium permanganate (of 1 to 5,000), of ichthyol (1 to 50), of silver nitrate (1 to 2,000), and of a saline solution (6 to 1,000) will be found useful.

(*b*) Irrigation with hot (100°–110° F.) solutions, by means of the double-current catheter, will be found efficient in allaying bladder inflammation, but for washing out thick pus or débris it is useless. Great care must be exercised when pursuing continuous irrigation not to overfill the bladder, and to see that the outflow is unobstructed.

For continuous irrigation, two-per-cent. boric acid, five per-cent. ichthyol, normal saline solution, or Thiersch's boro-salicylate mixture can be used with safety.

(*c*) Direct washing through a speculum in the urethra is of service when the bladder contains foreign matter, clotted blood, thick mucus, or shreds of tissue which would obstruct the outflow of urine and plug up a catheter. Insert a No. 8 or 10 cylindrical speculum, and through it introduce a straight glass irrigating nozzle of small calibre, and to this attach a rubber douche bag filled with a mild solution. Raise the douche bag high enough to insure a fairly strong outflow; direct the stream toward any collection of pus, etc., and in this way break up and wash out through the speculum, alongside the nozzle, such material as will pass out in no other way. Under no other circumstances ought hydrogen peroxide (two or three per cent.) to be introduced into the bladder. If it is applied, however, through a speculum, its action can be closely observed, and further it can be applied to any particular part of the organ. This plan of irrigation commends itself also in such cases as call for the use of the speculum for direct local application to the diseased mucous membrane.

(*d*) Instillations.—The introduction into the bladder of small quantities of a medicated solution, which is to be left in for from ten to thirty minutes, in order to secure a more protracted action, has been practised with success by Guion, of Paris. He uses for this purpose solutions of bichloride of mercury, 1 to 4,000 or 1 to 5,000, increasing the strength and quantity of the solution from time to time. From 2 to 5 gm. are slowly injected from a rubber syringe, and allowed to remain in the bladder for from fifteen to thirty minutes. Ten to twenty minims of pure ichthyol, or a two-per cent. silver nitrate solution, can be injected every fourth day in the same way. This plan is especially useful in gonorrhœal or other forms of trigonitis, or where there are localized inflammatory areas too large for local applications. Emptying and washing out the bladder must always precede instillations.

3. Direct applications to the diseased area through a speculum in the urethra affords a means of medicating localized inflammatory areas and circumscribed tuberculous patches and ulcers. A pledget of cotton is wound upon a slender applicator, dipped in the solution—moistened, not saturated—and applied directly to the diseased

spots. Silver nitrate, thirty grains to the ounce, will often cause considerable temporary pain or tenesmus: if it does, a ten or twenty grain solution must be used for subsequent applications, every four or five days. Pure ichthyol applied in the same way causes less burning, in many cases promotes more rapid healing of ulcers, has a very beneficial effect upon any portion of the mucosa to which it may be applied, and exhibits a marked effect in reducing pus formation.

Operative Treatment.

Emmet's Button-Hole Operation.—In some cases of cystitis which persist in spite of active treatment, and in others in which such treatment is impracticable, the bladder can be put at rest and perfect drainage obtained by the establishment of an artificial vesico-vaginal fistula.

Operation: Incise the bladder in the manner described for the removal of vesical calculi, and with a continuous catgut suture unite the vesical mucous membrane to the vaginal mucosa around the whole circumference of the opening. This will prevent spontaneous closure of the opening. Protect the vulva and thighs by an ointment, and give vaginal douches two or three times daily. If the thighs become excoriated, avoid the use of soap, and apply a two-per-cent. solution of silver nitrate once or twice daily.

When in the course of several months the cystitis has subsided, the edges of the fistula should be freshened and the fistula closed.

Clark's Vesical Balloon Treatment.—Kelly says that Dr. J. G. Clark's balloon treatment is applicable to all chronic cases in which the disease is not so far advanced as to render any active local interference dangerous, on account of the weakened condition of the patient. The plan, in brief (see Johns Hopkins Hospital Bulletin, February–March, 1896), consists of:

1. Cocainization of the external urethral orifice.
2. Introduction of No. 10 vesical speculum. Patient in knee-chest position.
3. Rolling the rubber bag into cigarette shape, and coating it with ichthyol-gelatin.
4. Introduction and dilatation of the bag, to the point of extreme tolerance; the bag to be allowed to remain in situation for from ten to twenty minutes.

Precautions.—The external meatus must be carefully cleansed, the hands of the operator thoroughly scrubbed and disinfected, and the solution sterilized.

The introduction and distention of the bag produce considerable tenesmus, and the after-pain necessitates the use of opium suppositories; but vesical irritation is said to diminish from day to day as the treatment is persevered in, and the bladder mucosa assumes a more nearly normal appearance.

Curettage of the bladder through the larger-sized speculum, through the vaginal incision, or through a suprapubic opening, has been successfully practised for the cure of a tuberculous ulcer and an intractable cystitis involving the superficial layers of the mucosa. It has also been used successfully in removing a limited area of diseased mucous membrane, which is afterward rapidly replaced by healthy tissue. First determine by previous cystoscopic examination just what portion of the bladder must be attacked. Place the patient in the dorsal position, insert the speculum, and thoroughly irrigate the bladder with saline or boric solution. Withdraw the speculum, introduce the curette into the bladder, and with the finger in the vagina for counter pressure, scrape the base and other predetermined areas. After curettage again irrigate the bladder, preserving shreds of the tissue for microscopic study.

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BLADDER OF THE MALE. (PATHOLOGICAL AND CLINICAL.)

—Malformations.—The development of the bladder may be arrested at various stages in its progress. Occasionally the septum which divides the rectum from the bladder is wholly or partially wanting, so that they freely communicate with each other, or, in extreme cases, form together a large pouch (cloaca) into which the intestine and ureters open. This condition of things may be associated with imperforate anus. Entire absence of the bladder has been reported, in which case the ureters opened directly into the urethra.

The most common fault of development, however, is the absence of the anterior vesical wall. This deformity, known as *exstrophy of the bladder*, is far more common in males than in females. It consists in a failure of union of the two halves of the body along the abdominal surface. The anterior wall of the bladder, and the abdominal wall over it, are wanting, and the pubic bones are generally separated by a considerable interval. The posterior vesical wall is consequently exposed to the air, and is pressed forward by the intestines behind it, thus forming a prominent tumor which may reach the size of the palm of the hand. This bulging bladder wall, owing to the constant irritation to which it is subjected, is much reddened and inflamed, and is usually covered with stringy alkaline mucus. In the lower part of this protruding mass may be seen the openings of the ureters, which are revealed by the constant little jets of urine escaping from them. They are sometimes much dilated. The rudimentary penis, which is always in a condition of complete epispadias, usually exists merely as a slight prominence, but may be of considerable size. It sometimes even retains a considerable power of erection, a point to be considered in the fitting of an apparatus. In connection with exstrophy are associated not infrequently herniæ of one or both sides. In the female, exstrophy is generally complicated with prolapse or procidentia uteri.

If the fault of development be not so extensive as in complete exstrophy, the abdominal walls may unite entirely up to the umbilicus, which fails to close and leaves a fistulous communication with the bladder through the still patent urachus. An even lesser degree of the same deformity is represented by a prolongation of the bladder up into the lower portion of the urachus. Sometimes the canal may be shut off from the bladder and form a cyst, or a series of cysts.

The suffering in a case of complete exstrophy is usually very great.

The treatment may be briefly summarized under three heads:

I. *Treatment by Apparatus.*—This method is applicable to—

1. All cases in which the defect is moderate and the condition of the patient is not sufficiently distressing to lead him to desire operation.
2. Cases in which plastic operations have been tried and have failed.
3. Cases in which the coexistence of other disease makes any operation inadvisable.

The rubber urinals manufactured for these cases are unsatisfactory, as they press upon and irritate the mucous membrane. The best apparatus is a silver or German silver shield, which arches over and protects the bladder, with a dependent portion into which the urine runs, and which communicates by a tube with a rubber bottle strapped against the leg. In order to get a well-fitting apparatus, it is a good plan to have first made a flexible, metallic ring, large enough to encircle the bladder. This is then bent and adapted to the inequalities of the surface, and, finally, the edge of the shield is fitted and soldered to it. The whole is held in place by a belt and perineal straps.

II. *Treatment by Plastic Operations.*—The utmost that we can reasonably expect to gain by any plastic opera-

tion for the relief of exstrophy is the greater comfort of the patient and greater ease in fitting apparatus. A truly retentive bladder cannot be obtained, and while the mortality of these operations is commonly supposed to be insignificant, Martin and Taylor believe it to be as high as thirty to forty per cent., so that it is obviously unwise to expect brilliant results from operations of this class. Plastic operations may be divided into two classes:

1. Those in which the skin of the abdomen is used in making the anterior bladder wall.

The flaps may be taken from a variety of sources, but the most satisfactory is Wood's operation, by which a flap large enough to cover the defect is taken from above and turned down so that the skin surface is innermost, and stitched in position. The raw surface of this flap may be covered by flaps drawn over it from the sides, by skin grafts, or left to granulate.

The objections to all operations in which the skin is used to restore the defect are the great tendency to calculus formation and the danger of irritation from hair growing into the bladder.

2. Those in which the mucous membrane alone is utilized. These operations depend on the possibility of getting enough mucous membrane to make a continuous canal from the openings of the ureters to the base of the penis. The urethra is then restored by an operation for epispadias, and thus in some cases the problem of fitting a urinal may be greatly simplified and the discomfort of the patient proportionately lessened. In selected cases this is an excellent procedure.

III. *Radical Cure by Implantation of the Ureters into the Bowel.*—The unsatisfactory results obtained by plastic operations and the discomfort incident to all forms of apparatus have led to attempts at radical cure of the condition by the removal of all that remains of the bladder wall and suturing the ureters into the bowel. The advantage of such an operation is the entire relief from the discomforts incident to the condition. The bowel soon becomes accustomed to its new function and the urine is passed at intervals closely approaching the normal. The dangers are twofold: those arising from the immediate effects of the operation and those resulting from infection of the kidneys by intestinal bacteria. The immediate mortality of the operation is by no means small, and though the statistics on the subject are too meagre to warrant a definite opinion, it is probably not far from that of other operations involving resection of the bowel. The more remote effects are those resulting from infection of the kidneys, and it is upon this issue that the ultimate value of the operation must be decided. The protection of the normal ureter from infection from the bladder is largely due to the anatomical arrangement by which the distention of the bladder closes the orifices of the ureters. This cannot be reproduced artificially and it has proved the most serious stumbling block. The tendency of the operation to produce stenosis of the lower end of the ureter, resulting in dilatation of the ureters and pelves of the kidneys, probably favors infection in the same way in which retention of urine favors the occurrence of cystitis.

The procedure is still too much in the experimental stage to permit of a positive opinion being given, but we cannot but regard it as an operation so dangerous as to be applicable only to a limited class of cases. Children

FIG. 496.—Exstrophy of Bladder in the Male (case of Dr. C. B. Porter). Boy of five years. Complete exstrophy. Penis rudimentary, showing condition of epispadias. Both testicles undescended and double inguinal hernia. Loose puckered skin below penis is the scrotum, and suggests the possibility of using it as a skin flap to cover the defect.

who will later be obliged to work, and adults who are competent to decide the question for themselves, would seem to be the most favorable subjects for this operation.

The limits of this paper will not permit of an extended discussion of the various forms of operation that have been proposed, for as yet no one method has attained a stable position.

Besides the malformations due to defective development, there are sacculated bladders in which occasionally the sacculi may even exceed the bladder in size. They are formed by herniæ of the mucous coat through the interstices of the muscular fibres, and may be recognized by the absence of a muscular coat over them. The bladder may also be divided into chambers, by partitions springing out from the walls.

HERNIA OF THE BLADDER.—This displacement may be congenital or acquired. Like other herniæ, it is sometimes brought about by violence or over-exertion. It may appear at any of the orifices in the lower abdomen through which other herniæ occur. The most common forms are inguinal in men, and vaginal or femoral in women. The hernial sac usually contains also portions of intestine and omentum, but may be occupied by a part of the bladder alone. The portion of the bladder in the sac is usually not covered by peritoneum, although exceptionally it may be. The presence of the bladder in a hernial sac is sometimes brought about by its adhesion to the intestine or omentum, which then drags it down with it. M. Berger observed such a case of inguinal hernia in which a portion of the bladder wall was drawn into the sac by adherent omentum. The bladder was opened by mistake, but was closed again by sutures, and the vesical wound was then fastened close to the inguinal opening. Some days later a fistula formed, which discharged urine intermittently, and closed spontaneously at the end of two months.

FIG. 497.—Exstrophy of Bladder in the Female (case of Dr. M. H. Richardson). Girl of sixteen years. Complete exstrophy. Pubic rami are separated four inches, the position of the ends being approximately shown by the pubic hair. Above is the bulging posterior bladder wall, while below, the thickened hypertrophied cervix protrudes from the vulva.

The *diagnosis* is to be made by the aid of the catheter, the tumor being emptied when the urine is drawn from the bladder. Pressure on the tumor, too, hastens the flow of the urine.

The *treatment* of hernia of the bladder is essentially that of hernia of other viscera except in so far as its existence brings with it additional dangers if treated palliatively—namely, those incident to the presence of cystitis; for inflammation may occur in a sacculation as the result of stagnation and consequent fermentation of the urine. Unless some concomitant disease forms a distinct contra-indication, an attempt should be made to cure the condition by radical operation. If this cannot be done, the sac should be supported by a pressure bandage, and the escape of urine should be aided by pressure during micturition. If, in spite of these precautions, the bladder is still incompletely emptied; the dangers arising from the constant presence of residual urine may to some extent be obviated by the routine use of the catheter, emptying the bladder at least once a day, preferably in the evening.

WOUNDS OF THE BLADDER.—The protected situation of the bladder renders it little liable to injury. In fracture of the pelvis, a sharp point or fragment of bone may penetrate its wall, or it may be injured by gunshot wounds, or by puncture with a sharp instrument. The treatment of this class of cases will be considered more at length under Rupture of the Bladder. The bladder may also be wounded by the unskilful use of instruments in lithotrity, or may be incised by accident during ovariotomy, hysterectomy, or other abdominal operation. In this latter case, if at once carefully stitched up, the wound usually heals without serious trouble.

The question of the advisability of closing openings in the bladder intentionally made, as in suprapubic lithotomy, must be decided in each individual case according to circumstances. While the ideal procedure is to close the bladder by immediate suture, the patient is often subjected to fewer risks if the wound is left open. The question must be decided by taking into consideration the general condition of the patient, the local condition of the bladder, and the trauma to which the bladder walls have been subjected during the operation.

RUPTURE OF THE BLADDER.—Ruptures of the bladder are either idiopathic or traumatic. According to their location, they may be also classed as intraperitoneal and extraperitoneal. Among the extraperitoneal are to be reckoned the partial and the subperitoneal.

Idiopathic ruptures usually occur in bladders altered by disease. A long-continued obstruction to the passage of the urine, as from a stricture or enlarged prostate, favors the formation of little herniæ of the mucous membrane through the meshes of the muscular tunic, and an over-violent strain during some exertion, or in the effort to empty the bladder, may rupture one of these little thin diverticula. The vesical wall is also sometimes weakened by ulceration, simple or malignant, and is thus rendered especially liable to give way. During labor, the distended bladder may be rup-

tured by compression between the abdominal wall and some part of the child or instrument used in the birth. The rent in this case may be into either the vagina or the peritoneal cavity.

Rupture of the healthy bladder is rarely produced, except by external violence in the form of a blow or crush. Probably it is sometimes also brought about by great

FIG. 498.—Apparatus for Palliative Treatment of Exstrophy. Above is shown the belt to go around the body, holding in place the metal shield of silver or German silver with a cup-shaped dependent portion into which the urine runs. On either side below are the perineal straps which fasten to the belt behind, and between them is the tube connecting the shield with the rubber receiving bottle fastened to the leg.

muscular exertion when the bladder is distended, even though it be healthy. In traumatic ruptures, the bladder is almost always full at the time of the traumatism.

Great violence to the hypogastrium is capable of producing a tear in the anterior wall of an empty bladder. This accident is to be explained as follows: The force applied to the hypogastrium carries the upper portion of the bladder, which is attached to the abdominal wall by the peritoneum and urachus, violently backward. The lower part of the bladder is held by the prostate, which is fixed by the pelvic fasciæ, and consequently a rent occurs in the anterior vesical wall just above the prostate. This is often accompanied by a considerable stripping up of the peritoneum. Intraperitoneal rupture uncomplicated can occur only when the bladder is full.

Symptoms.—When a rupture occurs a feeling of giving way or of a tear is often experienced. If the bladder has been painfully stretched by long retention, the first feeling may be of relief. Soon, however, pain follows, and is referred to the whole abdomen or to the pelvic region. This is followed in the majority of cases by shock and inability to walk. There may be desire, but want of ability, to micturate. Catheterism is usually easy, but obtains only a little bloody urine; not infrequently, on pushing the catheter further, a "second escape" of fluid is obtained.

Many of these symptoms may, however, be wanting. The pain is sometimes not very great; micturition may be possible, though even then usually difficult. The catheter may draw clear urine.

The principles of treatment in rupture of the bladder may be summarized by the following rules:

1. When an intraperitoneal rupture is made out, an immediate laparotomy, with suture of the bladder wound and subsequent drainage of the bladder, should be done.

2. When a reasonable doubt exists as to whether the rupture is intraperitoneal or not, an immediate laparotomy should be done.

3. If an extraperitoneal rupture is made out, and uncertainty exists as to the direction in which the urine is extravasated, a laparotomy should be done for exploration to ascertain how the drainage may best be placed.

4. In the case of fracture of the pubes, with evidence that urine is extravasated in the prevesical space, an incision should be made in the suprapubic region, a tube should be carried to the bottom of the effusion, and a median or lateral lithotomy should be done for drainage of the bladder.

Exception: Occasionally, in cases of severe injury with much shock, when a long operation could not be borne, a median lithotomy may be hastily done for drainage, and the opportunity may be taken for exploration of the position of the rent, to serve as a guide for further interference in case the patient rallies sufficiently.

In short, a laparotomy should be done in all cases of bladder rupture except in those which come under Rule 4, or those of such severity that they cannot bear more than the median operation.

TUMORS OF THE BLADDER.—Tumors of the bladder may be classified as follows, in the order of their frequency: Papilloma, carcinoma (carcinoma papillosum, epithelioma), myoma, fibroma, sarcoma.

Papillary tumors form, according to Professor Guyon, nine-sixteenths, according to Sir Henry Thompson, six-tenths, of all the new growths of the bladder. They are made up of very vascular branching papillæ, clothed with irregularly cylindrical epithelium. They are either pedunculated or sessile, and upon their character in this respect depends the difficulty of their removal. Their favorite seat is in the neighborhood of the trigonum, and they may attain the size of a pigeon's egg, or even larger.

They give rise to intermittent hæmaturia, and generally there is no pain in the early stages. Pain generally appears later, however, and may finally become quite constant and severe. Occasionally, by their pressure, they cause obstruction to micturition or to the entrance of the urine through the ureters. Finally, cystitis is usually associated with them. The hæmaturia may, however, exist for a number of years before other symptoms appear. Although benignant in their character, they finally cause death by the changes that they bring in their train. That they may take on a carcinomatous character seems also borne out by facts.

The *diagnosis* of papillary growths may be confirmed by means of the cystoscope, but the procedure is often complicated by the tendency of these tumors to bleed and render the fluid in the bladder turbid. This may to some extent be obviated by the use of an irrigating cystoscope through which the fluid in the bladder may be constantly renewed, but even then the view obtained is often unsatisfactory.

The *treatment* should consist in radical removal if possible. The suprapubic route is the best, as it gives a far better view of the bladder and enables the operator to plan his procedure with greater precision. If possible, the whole tumor, including its base, should be removed down to the muscular layer or even including it. In the latter case an immediate suture of the hole should be done. The suprapubic wound in the bladder may in some cases be closed, but this is possible only in favorable cases and when the hæmostasis is complete. In any case it will be well to provide constant drainage with an inlying catheter or perineal tube.

Primary carcinoma of the bladder occurs either in the form of papillary cancer, in which an indurated cancerous base is covered by papillæ resembling those of the simple papilloma, or as an epitheliomatous ulcer with hard indurated base and edges. Scirrhus is rarely met with, as is also an encephaloid form of the disease.

The *symptoms* resemble those of papilloma, but are

sooner or later associated with severe lancinating pains in the bladder and its neighborhood. The cancerous cachexia is often very marked.

The very noticeable tendency to late metastasis has led many operators to try to extirpate the growth. Recently, several attempts have been made to obtain radical cure by the removal of the whole or a large part of the bladder. This promises success only when the growth is confined to the fundus and has not invaded the surrounding tissues. In case the whole bladder has to be removed the ureters should be implanted in the vagina in the female and in the sigmoid flexure in the male.

In less promising cases much relief may be afforded the patient by suprapubic cystotomy and curetting the growth. This procedure may be repeated if necessary, and may decrease the suffering and lengthen the life of the patient considerably. Death ultimately takes place from generalization of the disease with symptoms which vary according to the organs implicated, the liver being almost invariably the seat of secondary deposits.

The *myomata* and *fibromata* can hardly be considered separately, as they usually occur in a mixed form, myofibroma or fibromyoma containing both fibrous and muscular elements. They are very rare. Gussenbauer, Volkmann, and the writer have removed tumors of this character. Gussenbauer's and the writer's patient recovered, while Volkmann's died. Tumors of this class may give rise to symptoms of obstruction, but do not as a rule cause hæmaturia or cystitis.

The writer has called attention to the condition known as pachydermia vesicæ, in which the mucous membrane of the bladder is changed into a membrane consisting of epidermoid cells. The relation to carcinoma appears to be close, and in the case reported* death ultimately occurred from that cause.

Primary sarcoma is extremely rare. The author has seen tumors of the prostate and bladder secondary to a round-celled sarcoma of the testis.

Besides the regular tumors mentioned above, *cysts* may rarely occur. They are sometimes congenital and contain hair, bones, etc.

Neurosis of the Bladder.—Spasm of the bladder, when not due to inflammation, is probably in the great majority of cases dependent upon an increased sensibility of the prostatic urethra (neuralgia of the neck of the bladder), causing by reflex action an excessive contraction of the detrusor urinæ muscle (see *Prostate, Diseases of the*).

In this connection we may mention the retention of urine which not uncommonly follows surgical operations, especially those involving the region of the perineum. It is due apparently to a reflex inhibition, the stimuli starting from the seat of the operation. This condition can often be relieved by the use of hot applications to the hypogastrium or perineum, and in women by spraying the vulva with warm water. If, however, all efforts to induce the patient to pass his urine fail, the catheter must be used before the distention of the bladder becomes extreme, and when once started the use of the catheter may have to be continued for several days before the power of voluntary micturition returns.

Paralysis of the Bladder is usually consequent upon some disease or injury of the nervous system. The lesion may exist in peripheral nerve trunks, or may be located either in the reflex or in the motor centre (spinal cord or brain).

The loss of power may be total or partial. When the paralysis is complete (which occurs usually in connection with paraplegia), the sphincters, both voluntary and involuntary, are also paralyzed, and after the accumulation of the urine produces a tension in the bladder great enough to overcome the resistance in the urethra, a leaking of the overflow commences. As sensation is lost in these cases the distention of the bladder and escape of the urine are often not perceived by the patient.

If the paralysis comes on slowly, as it may do in cases of spinal sclerosis, tabes dorsalis, and in Pott's disease, it first makes itself known by the diminution in the force of the stream, and the increase in the time occupied in urination. When the paralysis is extreme, the pressure of the abdominal muscles furnishes almost the only driving power, and the stream dribbles perpendicularly from the meatus.

As the act of urination becomes more and more incomplete the amount of residual urine slowly increases until finally the bladder becomes distended and the overflow begins to escape, either intermittently or constantly. In either case a partial power of urination may be preserved. When the distention becomes extreme, the pressure is transmitted back to the kidneys, and may be so great as to cause suppression of urine and uræmia.

Besides this true paralysis, dependent on nervous lesions, there is also occasionally a partial or temporary loss of power, dependent upon general disturbances of the nervous system, such as hysteria, nervous prostration, and the debility following sexual excesses.

Atony of the bladder, by which is understood a weakness or loss of contractile power of the muscular coat, is not infrequently seen as a result of overstretching, which may be brought about by voluntary retention, or may be the result of obstruction in the prostate or urethra. It is considered in this connection, not because it is due to any nerve lesion, but because the local condition and its treatment are closely allied to paralysis. The condition is closely analogous to the enfeebled condition induced in any voluntary muscle which is persistently kept upon the stretch.

The *diagnosis* of paralysis or of atony of the bladder, when existing in any marked degree, is usually not difficult, although sometimes the constant escape of urine from an overfilled bladder leads to the erroneous idea that true incontinence exists. This mistake will be avoided by an examination of the hypogastrium, where the bladder, if full, will be easily detected. Any doubt as to the character of a central tumor above the pubes should lead to the passage of a catheter.

Atony of the bladder, if dependent upon some condition that can be relieved, may be recovered from. The chance of a favorable termination is, however, much more doubtful in old and worn-out subjects.

True paralysis occasionally depends upon some nerve lesion (meningitis, apoplexy, syphilitic inflammation, fracture of spinal column), which admits of more or less complete recovery. In the majority of cases, however, the loss of power is permanent. The cystitis, which is its most uncomfortable accompaniment, may be kept under control by proper care.

The *treatment* in cases of paralysis and atony should consist, first, in the systematic use of a catheter. The bladder ought to be emptied at least as often as once in the twenty-four hours when the loss of power is partial, while in complete paralysis this should be done four or five times a day. In addition to this, irrigation should be regularly employed, especially when cystitis has already started. If the loss of power be partial, the washing may be done with cold solutions, which have a stimulating influence upon the detrusor muscle. The systematic use of urotropin in doses of gr. v. to x., three times a day, appears to have a distinct influence in postponing the advent of cystitis and in rendering it less severe. Cold bathing of the abdomen and sacral region may also be useful.

Electricity is sometimes used with advantage. One electrode should be placed over the sacrum, and the other just above the symphysis pubis, in the perineum, or within the bladder itself.

Besides these local measures of treatment, the strength of the patient should be supported as far as possible by regulation of the diet, by exercise, and even by change of climate if it seem wise.

Strychnine and ergot are both thought to have a beneficial effect upon the muscular wall of the bladder, and general tonics are of use by their effect upon the general system.

* American Journal of the Medical Sciences, February, 1891.

When the power of retention is lost, a urinal becomes a necessity.

INFLAMMATION OF THE BLADDER (CYSTITIS).—If we could confine the term cystitis to those cases only in which true inflammation exists, the task of making a clear and concise statement with regard to the etiology would be much simplified; but there are many cases in which some of the symptoms are present and which have long been considered as a variety of cystitis in spite of the fact that the process never goes farther than an active hyperæmia. The more recent methods of examining the female bladder have shown that congestion may and does exist without true inflammation, and it is probable that the same causes may act on the male bladder and cause the cases of transient cystitis which are so difficult to classify.

The *etiology* of cystitis has been the subject of much careful bacteriological study of late years, as a result of which the importance of the rôle played by infection has been more and more appreciated. Many varieties of cystitis which have long been believed to be the result of "irritating urine," "taking cold," "gout," etc., have been shown to be due to infection, and while we are as yet hardly in a position to deny that certain conditions of the urine may cause an aseptic inflammation, the number of cases properly referable to this cause is comparatively few.

There are five routes by which bacteria may reach the bladder:

I. By the urine from the kidneys.

II. Through the urethra on instruments.

III. Through the blood.

IV. From the rectum and sigmoid flexure, either by passing through the peritoneum or through retroperitoneal lymphatics.

V. By direct extension from adjoining areas of suppuration, *e.g.*, infected urethra, prostate, or pelvic abscess.

A discussion of the comparative frequency of these various sources of infection would exceed the limits of this paper, but a few interesting observations may be noted.

Posner and Lewin found that after ligation of the rectum in animals, intestinal bacteria soon appeared in the urine and disappeared when the ligature was removed. Werden succeeded in producing cystitis by causing an artificial retention and making an abrasion on the rectal mucous membrane.

The constant presence of the typhoid bacillus in the urine of typhoid fever is now generally accepted and is doubtless the cause of many of the cases of cystitis occurring in this disease; but the discovery is even more valuable as suggesting the possibility that a similar condition exists in other acute infectious diseases, as the acute exanthemata, acute polyarthritis, etc., with the bacteriology of which we are less familiar.

The bacteria most commonly found in cystitis are:

I. The group of bacteria of which the bacillus coli communis is the type and which are found in more than one-half of all cases of cystitis.

II. The proteus vulgaris of Hauser, a common intestinal saprophyte.

III. The staphylococcus aureus, albus, and citreus.

IV. The streptococcus pyogenes.

V. The tubercle bacillus.

All of the above-mentioned bacteria are capable, under favorable circumstances, of decomposing urea, but the colon group and the tubercle bacilli do so much less rapidly, and in the cases in which they occur the urine is more likely to be found acid.

In rare instances the gonococcus causes a true cystitis, but it is probable that most of the cases occurring in the course of a gonorrhœa are due to pyogenic organisms or that the true condition is one of posterior urethritis rather than cystitis.

Of late years several observers have called attention to a condition which they have called bactinuria, in which bacteria are constantly present in the urine without, however, causing any cystitis, showing that under normal conditions the bladder is not very susceptible to infection. The injection into the bladder of pure cultures of virulent bacteria has also failed to cause cystitis in all but a very small proportion of cases, showing that some predisposing cause is necessary in order to allow the bacteria to obtain a foothold, and this cause is to be found in the presence of hyperæmia, which is a very constant precursor of cystitis.

Causes of Hyperæmia.—White and Martin have summarized the causes of hyperæmia as follows: (1) Retention of urine; (2) trauma; (3) muscular contractions of abnormal frequency; (4) abnormal conditions of the urine; (5) tumors or calculi; (6) surface chills; (7) sexual excesses; (8) heart lesions; (9) lesions of the central nervous system.

Hyperæmia may be considered a predisposing cause of cystitis; and of the various causes of hyperæmia, retention of urine is by far the most common. It is the constant precursor of the cystitis associated with hypertrophy of the prostate, stricture of the urethra, paralysis of the bladder, and many of the cases of cystitis occurring in acute infectious diseases and after surgical operations. In all these cases the use of a catheter may lead the way to infection, but it must not be forgotten that in many cases the urine itself contains the infectious agent, even before the catheter has been used.

Under trauma we may include all cases following fracture or injury to the pelvis, injuries to the bladder during childbirth, or surgical or gynecological operations.

Abnormal conditions of the urine may produce a hyperæmia by the presence of drugs, as cantharides, turpentine, cubebs, and copaiba. A very acid urine may act in the same way, more especially if it contains minute crystals of uric acid or oxalate of lime. Here we may include the obscure cystitis occurring in gout and chronic rheumatism, provided always that another cause, such as obstruction to the flow of urine, does not exist.

Tumors and calculi by their very presence cause hyperæmia, and it is indeed surprising how long one of the above conditions may exist without the occurrence of cystitis.

Surface chills may cause acute pelvic congestion and in this way lead to congestion of the bladder, but except in the case of old men with enlarged prostates, this cause is probably not of frequent occurrence.

Sexual excesses, by giving rise to congestion of the neck of the bladder, may in some cases cause true vesical hyperæmia; but in many cases, at least, it is only the lighting up of an old posterior urethritis that causes the symptoms.

Heart lesions, by producing a chronic passive congestion of the whole venous system, may readily be a predisposing cause of cystitis.

We may summarize the etiology of cystitis as follows:

1. Infectious cystitis, due to the action of bacteria on the mucous membrane of the bladder, already rendered susceptible by the presence of hyperæmia. This class includes the vast majority of all cases, and we are tempted to suppose that when our knowledge of the bacteriology of the bladder becomes more complete, the number of cases properly ascribed to other causes will be found to have dwindled still more.

2. Aseptic cystitis due to the action of irritants the nature of which is uncertain. To this class we may refer some cases occurring in gout, but we are inclined to question the soundness of the classification, and also some cases of so-called idiopathic cystitis the etiology of which cannot be defined.

3. Cases of mild, transient cystitis in which it is questionable whether true inflammation exists and which are probably akin to the vesical hyperæmias which we see in women.

Pathology.—The pathological appearances vary with the severity of the inflammation. In simple catarrhal cystitis, the mucous membrane is more or less swollen and reddened, with the minute vessels sometimes visibly injected. This redness is usually most marked on the summits of the folds or rugæ, which may be studded

with punctate hemorrhages if the inflammation has been of considerable intensity. Streaks of viscid mucus cover to a greater or less degree the inflamed surfaces. These appearances may be confined to the neighborhood of the urethral opening (partial catarrh, catarrh of the neck of the bladder), or may be diffused over the whole mucous membrane (universal catarrh). Even in this latter case, however, the evidences of inflammation are usually most marked about the urethra and trigone.

A loss of the superficial epithelium (erosion) sometimes occurs, and this is occasionally associated with the formation of false membrane (croupous inflammation). A severe inflammation sometimes leads to ulceration which may be diphtheritic in character. Rarely sloughing of considerable portions of the mucous membrane, and also of the muscular coat, follows long retention. When inflammation extends to the deeper layers of the bladder, the tissues are much thickened and infiltrated with pus, which may lead to the formation of abscesses. These may extend outward through the surrounding cellular tissue, and open spontaneously into the vagina, rectum, neighboring coil of intestine, or into the peritoneal cavity. Occasionally, however, they perforate the mucous membrane, and open into the bladder itself.

Dr. Samuel Alexander has described a condition known as nodular or follicular cystitis. It is characterized by intense congestion and the appearance, especially in the region of the trigonum, of hyperplasia of lymph nodes, somewhat resembling the condition of the ileum in typhoid fever.

A long-standing catarrh causes a brown or gray discoloration of the mucous membrane, often with considerable dilatation of the veins, especially about the urethral opening. The surface is covered with muco-pus which is often extremely viscid and adherent. The mucous membrane and parts beneath are much thickened and infiltrated. If an obstruction has been the primary cause of trouble, the muscular coat of the bladder is greatly hypertrophied and forms interlacing bands which stand out like the columnæ carneæ of the heart (*vessie à colonne*). At the same time that the bladder is thus thickened, it is often also dilated (eccentric hypertrophy). Little herniæ of the mucous membrane, between the fibres of the muscular coat, are not infrequent. Lastly, inflammation of the bladder may be tuberculous in character, in which case the mucous membrane of the bladder, the prostate, ureters, and even the pelves of the kidneys may be the seat of characteristic ulcerations.

Clinical History.—In cystitis the most prominent, almost unfailing, symptom is a *frequent desire to urinate*. This varies greatly in degree, from a slightly increased frequency of micturition which escapes notice to an almost constant, painful tenesmus of the bladder, compelling straining efforts which accomplish only the voiding of a few drops at a time. This symptom is in no sense pathognomonic, as it is common to all affections which increase the irritability of the neck of the bladder. The symptom next in importance is *pain*. This may be very slight, and felt only just before and at the end of micturition. It may, however, be almost constant and severe in character. The pain is ordinarily referred either to the hypogastrium, the perineum, or the end of the penis, but when severe assumes a lancinating character, shooting down the thighs, through the lumbar and sacral regions, and to the testicles. Pain referred to the hypogastrium, especially if accompanied by tenderness in that region, is usually indicative of inflammation affecting the body of the bladder. When the neck of the bladder is especially affected, the pain is referred to the perineum and to the end of the penis. These two prominent symptoms are usually accompanied by some *fever* in cases of acute universal cystitis. In inflammation of the neck of the bladder fever may be present, but is often slight or entirely wanting. In chronic cystitis there is ordinarily no febrile reaction. *Retention of urine* occurs rarely as a complication: it is most common in cystitis following gonorrhœa, when a deep urethritis exists, and it is then due to a spasmodic contraction of the constrictor urethræ muscle.

Constipation is almost always present, and not only do the difficult movements of the bowels greatly aggravate the pain in the bladder, but experiments would suggest that the condition may favor a fresh supply of infectious organisms from the intestine.

Cases of chronic cystitis, dependent upon conditions which cannot be removed, run a protracted course with many ups and downs. Errors in diet, exposure to cold, over-exercise, or any excess in alcoholic liquors or in sexual excitement, bring fresh accessions of inflammation, which are recovered from with ever-increasing difficulty, especially at an advanced age. Finally, some serious complications, such as inflammation of the pelvis and secreting portion of the kidney, ulceration, possibly diphtheritic, of the bladder wall, formation of an abscess, septicæmia or uræmia, appears and quickly closes the scene.

The character of the urine is of great importance in supplying information as to the condition of the bladder. In a mild case, the urine may be acid and but slightly cloudy. When the urine is allowed to stand for some time a light sediment separates, consisting of muco-pus, with usually a considerable number of flat epithelial cells. As the cystitis increases in severity, the urine becomes more and more turbid, from the increasing amount of pus; and in addition to the squamous surface epithelium, rounded cells, derived from the deeper layers of the bladder mucous membrane and from the prostatic urethra, make their appearance. If, finally, alkaline fermentation occurs, the urine acquires a pungent ammoniacal smell, and the pus assumes a thick ropy consistency. Bacteria are also present in great number, giving a cloudy appearance to the urine even after the pus has settled out of it. Strongly ammoniacal urine causes the pus cells to swell to several times their natural size, and finally to dissolve. Casts, if present, are similarly dissolved, a fact which should be borne in mind when examining for evidence of coincident kidney disease. Blood corpuscles may be present in cases of cystitis of some severity, but in ammoniacal urine are quickly dissolved. The blood-pigment in this case imparts a brown or smoky color to the urine, which is quite characteristic.

Occasionally blood in considerable quantities may be passed and easily recognized. Besides these cellular elements many crystals are found in the urine of cystitis. In strongly acid urine, crystals of uric acid or oxalate of lime are not infrequent. If they are in considerable quantity, and especially if of large size, they may be suspected as the possible predisposing cause of the inflammation. In ammoniacal urine, the crystals usually found are those of triple phosphate and urate of ammonia, with which are often associated amorphous phosphates in a finely granular form. If the bladder inflammation takes on a diphtheritic character, bits of discolored diphtheritic membrane may appear in the urine. Gangrenous inflammation of the bladder wall, which is usually the result of severe injury, long-continued pressure, or of the breaking down of a new growth, gives the urine an excessively fetid character. The admixture of blood more or less decomposed gives it a brownish, smoky, or green color, and the sediment contains much granular matter and large granular corpuscles, besides the various cells and crystals found in severe cystitis. Occasionally especially as a result of long-continued pressure, considerable portions of the mucous membrane are thrown off, and may be recognized as such in the sediment. In the case of a sloughing new growth, characteristic forms (villi) can frequently be found under the microscope.

Interstitial (parenchymatous) cystitis causes a train of symptoms much more severe than those occasioned by a simple catarrhal inflammation. There is ordinarily high fever, sometimes accompanied by chills. The inflammatory infiltration of the bladder walls stiffens them, and by hindering their contractions makes complete expulsion of the urine impossible. The ureters, or the urethra, may be obstructed by abscesses, or by inflam-

matory swelling about the orifices. If an abscess breaks into the bladder, the appearance of a greatly increased quantity of pus in the urine is followed by a decided improvement in symptoms. If the opening takes place into the intestine, the symptoms also improve, although they may speedily resume their serious character if the intestinal contents get into and infect the abscess cavity. If the pus finds its way into the perivesical connective tissue, it may work outward and point either above the pubes or in the perineum, in which case its approach to the surface is heralded by preceding œdema and induration. Occasionally, perforation takes place into the peritoneal cavity, and speedy collapse and death is the consequence. Infiltration of urine is a very rare consequence of inflammatory rupture of the bladder wall, and its spread is limited by the attachment of the pelvic fascia along the brim of the pelvis. A localized pelvic abscess may thus be formed and require drainage.

Diagnosis.—The diagnosis of a cystitis is usually a matter of tolerable ease, if the symptoms and the condition of the urine are carefully inquired into.

Pure neuroses of the neck of the bladder, which may cause similar subjective symptoms, do not cause the alterations in the urine which accompany inflammation.

Pyelitis, which also gives rise to pus in the urine, is to be distinguished by pain and tenderness in the kidney region and by a temperature higher than that of an uncomplicated cystitis. The presence in the urine of small caudate cells from the pelvis of the kidney is important, but their identification is a matter of some difficulty. The discovery of casts is always extremely suggestive, especially in the presence of other symptoms of pyelitis. Cystitis occurs, however, not uncommonly with pyelitis, so that the symptoms of the two diseases may complicate each other.

Urethritis is usually to be distinguished by the symptoms and by the presence of a urethral discharge. Occasionally, however, an inflammation in the deep urethra may present features of similarity with cystitis. If, in such cases, the urine is passed in two portions, which are received in different vessels, the pus will be contained in the first part if the urethra alone be affected.

Prostatitis resembles in many symptoms a partial cystitis. The pain of prostatitis is, however, referred to the rectum more than is the case in cystitis. The test of passing the urine in two or even in three portions shows that the inflammation is anterior to the bladder, and, finally, palpation of the enlarged hot and tender prostate through the rectum completes the diagnosis. The coincidence of prostatitis with cystitis is not uncommon and should always be considered.

The character of the urine gives, as has been shown, valuable information as to the severity and character of the inflammation. Croupous, diphtheritic, and gangrenous cystitis can generally be merely suspected, although shreds of tissue may sometimes be obtained and put the matter beyond doubt. Interstitial cystitis may sometimes be definitely made out when the posterior bladder wall is affected and can be felt through the rectum. The bladder may even form a defined tender tumor which can be felt from without. Usually, however, this condition can be surmised only from the history and the severity of the general symptoms. The formation and opening of an abscess would be confirmatory.

Prognosis.—Acute cystitis, when not dependent upon some previously existing chronic condition, may with proper care run its course in from two to three weeks. It is rarely severe enough seriously to threaten life. Chronic cystitis, if dependent on some curable condition (stone, stricture, etc.), may be recovered from after the removal of the predisposing cause, provided that the long duration of the malady has not induced permanent organic changes in the bladder wall.

Advanced age and a weak constitution render the prognosis much less favorable. When the disease is the result of some condition which cannot be removed (enlarged prostate, tuberculosis, inoperable tumor, etc.), recovery cannot be expected, although a considerable amelioration of symptoms may be accomplished by appropriate and thorough treatment. The appearance of phlegmonous, diphtheritic, or gangrenous inflammation, with or without the formation of abscesses, makes the prospect of recovery extremely doubtful.

Prophylaxis.—Many cases of cystitis could no doubt be avoided by intelligent care. Careful management of an acute gonorrhœa, or of a stricture or enlarged prostate, would often enable the patient to escape the cystitis which they so frequently induce. The most important prophylactic measure, however, is a thorough observance of aseptic precautions in any and all operative procedures upon the bladder. All metal and rubber instruments should be thoroughly cleaned and boiled immediately after using, and should then either be kept in an aseptic case or cleaned again immediately before using. The problem of cleaning gum elastic and webbing catheters is more difficult, and they can rarely be used with safety more than a few times. They should be cleaned with soap and water to remove the oil and then washed carefully with corrosive sublimate 1 to 1,000. Recent methods of sterilizing catheters with formaldehyde vapor appear to be satisfactory and if further experience proves such to be the case, it will add much to the safety of urethral surgery.

In all cases in which there is any doubt as to the healthy condition of the urethra it is wise to give it a preliminary washing with some mild antiseptic, and in cases in which urethritis exists, it is well to repeat this after the use of any instrument.

Of the great variety of lubricants one should be selected which is aseptic and non-irritant. Most of the antiseptic lubricants, and especially those containing carbolic acid or eucalyptus oil, are irritating. Simple vaseline put up under aseptic precautions in collapsible tubes is perhaps as useful as any. If it is desired to have a lubricant which will remain sterile even though exposed to the air, boric acid may be added in the proportion of ʒ i. to ℥ i.

Treatment.—In acute cystitis, whether universal or partial, the thing of first and greatest importance is rest. Rest should be absolute in bed, in a horizontal position, or with the hips slightly raised. The bladder, irritated and intolerant of its contents, should be soothed by full doses of some anodyne to lessen as much as possible its over-excitability, and to quiet its constant spasmodic activity. The anodyne is usually best administered in the form of a suppository, a favorite combination being opium or morphine, with either hyoscyamus or belladonna. Not infrequently, however, it will be found wise to give the anodyne by the mouth, as rectal absorption is slow and sometimes unsatisfactory. If the pain is due mainly to the spasmodic action of the bladder, hyoscyamus or belladonna sometimes suffices to relieve it, and when either of these is efficient it is preferable to opium, which is objectionable from its constipating properties, even when it does not disagree with the stomach. Codeine will also be found useful, especially in the less severe cases. If, however, hyoscyamus, belladonna, or codeine do not control the pain, opiates should at once be resorted to; and these should be given in full doses, as a really curative effect is to be expected from the relief of spasm.

Heat, wet or dry, over the hypogastrium and perineum will often be of use, and if well applied will accomplish more than a hot hip-bath, which is commonly used, but which has only a transient effect. A hip-bath, if given, should be very hot, and the patient should be in it but a few minutes (four or five at the outside), as the necessary position, if maintained for any length of time, favors congestion of the pelvic organs, and to a great extent counteracts the otherwise good effects of the heat.

Medicinal treatment intended to modify the condition of the urine may be beneficial in two ways: first, by increasing the amount and consequently diluting the urine; and, second, by affecting the reaction and rendering it a less favorable medium for the growth of bacteria.

The most simple and generally an efficient method of

increasing the amount of urine is to urge the patient to drink at least two quarts of water or milk in the twenty-four hours; if more can be taken, so much the better. To this may be added cream of tartar water, or citrate of potassium, both of which are mild diuretics and tend to stimulate the action of the kidneys. In this way the amount of urine can generally be kept sufficiently large markedly to dilute it. The vegetable diuretics, buchu, triticum repens, uva ursi, etc., are less used now than formerly, and they are not notably more efficient than the milder measures above mentioned.

Of the drugs which owe their power to the fact that they are excreted in some form in the urine, benzoate of sodium, boric acid, sandalwood oil, and urotropin are the most valuable. If the urine is ammoniacal, as is not infrequently the case, its irritating properties are thereby much increased, and the use of some drug to render the urine acid is distinctly indicated. The most efficient are benzoate of sodium and boric acid in doses of from gr. v. to x. every three to four hours, according to the reaction of the urine and the tolerance of the patient. Sandalwood oil has a soothing effect, especially when the inflammation is most marked about the neck of the bladder, but it is taken with difficulty by some patients and should always be given in capsules.

The introduction of urotropin is so recent that a definite opinion in regard to its value cannot be given. It owes its value to the fact that it is excreted in the urine as formaldehyde and thus inhibits the growth of bacteria.

The work of M. W. Richardson has shown that it is very efficient when used against the typhoid bacillus in the urine, and a somewhat limited clinical experience suggests that it may prove a valuable addition to the list of urinary antiseptics.

Besides this strictly medicinal treatment, the diet should be carefully regulated, only bland, unirritating articles of food being allowed. Alcohol in every form should be interdicted, and tea and coffee should be avoided or taken very much diluted. The bowels are to be kept gently open, and especial care in this direction is needed when opiates are being used.

When the inflammatory process is being combated in this manner, the predisposing cause of the cystitis should be sought for and if possible removed. If an irritating diuretic is being taken it should be stopped. A rheumatic or other constitutional cause should receive appropriate treatment. Retention of urine, if it exists, should be relieved by the use of a catheter. When, however, the cause of the cystitis is one which requires an operation for its removal (calculus, stricture, etc.), it is usually best, unless in case of emergency, to defer interference until the acute stage of the disease is past.

If the inflammation is so severe as to involve surrounding parts and to give rise to pericystitis, the appearance of abscesses must be watched for with great care, as their early detection and evacuation is of cardinal importance.

Ordinarily an acute cystitis yields to careful treatment, and recovery is complete. If, however, the acute condition does not subside under treatment an examination should be made to discover whether there is not some underlying cause, as calculus, tumor, stricture, or enlarged prostate, which must then receive the appropriate treatment.

Almost all cases of subacute or chronic cystitis, especially when associated with foul, decomposing urine, are to be greatly benefited by thorough irrigation; and this measure may even be employed in acute cases if the urine assumes a fetid character.

When properly performed this washing out of the bladder usually does much good, but if done carelessly or improperly it may cause serious harm.

Sir Henry Thompson directs that no more than two ounces of fluid shall be thrown into the bladder at one time. This rule is a good one in cases of acute cystitis, or when the bladder is greatly contracted or especially irritable. In many chronic cases, however, it is not only safe, but wise to somewhat distend the bladder with the injected fluid, the object being to spread out the folds of the mucous membrane so as to insure the thorough removal of fermenting mucus and the contact of the irrigating fluid with all parts of the bladder wall. If the injection is made slowly, the bladder ordinarily tolerates the distention well.

With regard to the injecting apparatus, a syringe forces the fluid in with irregular, intermittent force, and imperfections in the valves make it often a matter of uncertainty whether the proper amount has flowed into the bladder or not. These disadvantages are avoided by the use of a fountain syringe; and if a clear glass bottle is used as the reservoir, it can be easily kept clean, and the exact amount of the fluid which flows into the bladder can be readily seen and exactly measured by a scale fastened upon the side of the bottle. The force of the stream is to be regulated by adjusting the height of the reservoir above the bladder. This should never be greater than from one to two feet, or the bladder may be subjected to a dangerous strain. It is also important to stop injecting the moment the patient feels the least desire to micturate.

The simplicity of this apparatus is of great advantage in point of cleanliness, and patients quickly learn to manage it for themselves.

The catheter used should be of soft rubber, if such can be introduced; if not, that form which passes with least irritation is the best, whether bulb-pointed or coudée, gum-elastic (English) or silver. A double-current catheter is less good than one with single calibre, for the continuous stream does not cleanse the bladder so quickly as is done by alternate filling and emptying, and the necessarily small size of the escape tube in a double instrument prevents the ready exit of thick pus or mucus. The bladder may also be irrigated without the use of a catheter by means of a fountain syringe with an olive-tipped nozzle. This is held tightly against the meatus and the fluid allowed to distend the urethra, which will "balloon" out as far as the triangular ligament. In this way the anterior urethra may be thoroughly washed, and then by raising the douche bottle higher, sufficient pressure may be obtained to overcome the resistance of the compressor muscle and the fluid will run back into the bladder. The whole operation is carried out without introducing any instrument beyond the meatus, and this method of irrigation has of late found considerable favor among surgeons in some parts of the country. Many drugs are added to the injection fluid, either with the object of disinfecting the contents of the bladder or of acting topically upon the mucous membrane.

The most useful solutions with which to irrigate the bladder are a solution of borax (biborate of sodium), a drachm to the pint; boric acid one per cent., and chloride of sodium two drachms to the pint. The stronger antiseptics, as corrosive sublimate and carbolic acid, are too irritating to be often useful. Occasionally when the secretion of pus and mucus is very abundant, and especially in chronic cases, permanganate of potassium 1 to 5,000 to 1 to 10,000 will be found useful for its astringent action.

In phosphaturia very dilute hydrochloric or nitric acid (one or two drops of strong acid to the fluidounce of water) may assist by their solvent and astringent action.

Lastly, we come to speak of nitrate of silver, which if properly used is productive of much good, but if abused or improperly employed may do decided harm.

An obstinate chronic cystitis which does not yield to milder measures is sometimes greatly benefited by the use of a weak solution (one-tenth to one-fifth per cent.) of nitrate of silver. This gives the best results when it is used every second or third day, some milder injection being substituted on the intermediate days. The amount of pus is usually very decidedly diminished by these applications.

Occasionally, it happens that adhesive mucus so clogs the eye of the catheter as to prevent the escape of the urine. This may be removed by attaching a rubber tube full of water to the catheter and then dropping its

free end into a vessel upon the floor. The weight of this column of water usually exerts sufficient suction to draw out the obstructing mucus.

In chronic cystitis, the local treatment is more to be relied upon than medication.

In the majority of cases the measures that have been suggested will accomplish, if not a cure, at least a palliation of symptoms which brings comparative comfort to the patient; occasionally, however, a case is met with in which the bladder has suffered such decided organic changes that the passage of urine through it, with its alternations of expansion and contraction, is sufficient to keep up an aggravated inflammation. In spite of every care the patient begins to suffer from septic absorption, and death seems imminent.

Under such circumstances, constant drainage by means of a catheter should be tried. This will often have the effect of giving the bladder the desired rest and allowing the reparative process to begin. If this is not successful, cystotomy holds out a last hope. An opening through the perineum, by providing drainage and rest to the bladder, allows it time and opportunity to recover itself. This treatment was first applied to a case of this sort by the late Dr. Willard Parker, of New York, in the year 1850.

The necessary opening may be made either laterally through the prostate, as in lithotomy, or may enter the membranous urethra through the middle line, and through this opening the prostatic urethra may be readily dilated with the finger so as to admit the introduction of a good-sized tube. The latter method has the advantage of injuring no important structures, whereas the former promotes more thorough drainage. Whenever an incision through the perineum is practised it should be made the opportunity for a thorough exploration of the bladder, as an unsuspected cause for the cystitis may sometimes be found.

Stone in the Bladder.—The stones which are commonly found in the bladder may be roughly divided into uric acid, oxalate of lime, and phosphatic calculi. A stone composed wholly of any one of these constituents is, however, not common, the usual condition being a mixed form, in which a uric acid or oxalate of lime nucleus is covered by a phosphatic crust; sometimes a succession of layers may be formed by alternating deposits of different components. The phosphates are almost always combined with alkaline urates and carbonates. Other substances, such as cystin and xanthin, in rare instances form concretions in the bladder.

For purposes of surgical classification, calculi may be divided into those which form in an acid and those which form in an alkaline urine. The former class includes the uric acid and oxalate of lime stones, while the soft concretions, composed mainly of phosphates, belong to the latter.

"The researches of Rainey, Harting, Ord, Ebstein, and others, indicate that the formation of stone is not a simple process of deposition of salts existing in excess in the urine. Indeed, instances are of everyday occurrence in which uric acid, the urates, oxalate of lime, or the phosphates are present in solid form for long periods of time in the urine without leading to stone formation. The investigations of these observers have shown the crystalline substances of the urine to follow the law of 'molecular coalescence' laid down by Rainey and elaborated by later observers: which is briefly, that 'in the presence of colloid or albuminoid substances crystalline materials become spheroidal in shape and coalesce in rounded form.' Following this law, in the urinary passages crystals of uric acid in their usual rhomboidal shape may for long periods be thrown down, washed along, and passed out with the urine without showing any tendency to form concretions. Finally, the irritation of the urinary tract leads to the exudation of albuminoid material, which, acting on the crystals, changes their molecular form and creates in them the tendency to coalesce. The necessary albuminoid material may be supplied in other ways. Necrotic bits of tissue are, as is well known, likely to be encrusted with lime salts. Masses of bacteria and bits of blood clot are also found in stones, but what part they play in the formation of the stone is not clear. The concretion, once started, continues to act as an irritant to the wall, and so continues to be supplied with an albuminoid envelope, in which successive layers of spheroidal crystals are deposited." *

The formation of phosphatic stones is almost invariably the result of inflammatory conditions in the urinary tract leading to alkaline fermentation of the urine.

Calculi may form in any part of the urinary apparatus. When they originate in the kidney they usually find their way, sooner or later, into the bladder. This may be accomplished painlessly, or may be accompanied by severe pain (nephritic colic).

After reaching the bladder they either pass out through the urethra and cause no further trouble, or they remain and gradually increase in size until their presence is revealed by the symptoms to which they give rise. Their detention in the bladder is rendered extremely probable when some obstruction to micturition has caused dilatation with residual urine, or when sacculation of the bladder exists. A stone thus retained in the bladder continually grows by accretion. So long as the urine remains unchanged, the character of the stone continues the same; when, however, the urine, formerly acid, becomes alkaline from the occurrence of fermentation, the soft salts (phosphates, etc.) are deposited on the hard basis of calcic oxalate, or uric acid.

Stones usually occur singly, but sometimes many, up to several hundreds, are found in one bladder.

Single calculi are moulded into a more or less oval form by attrition of the vesical walls. The surface may be tolerably smooth, as is often the case with uric acid calculi, or rough and granulated, as is more commonly seen in phosphatic stones; and finally, those composed of oxalate of lime are usually covered with rough, often sharp projections, giving them a knobby, irregular outline, which has suggested their distinctive name of mulberry calculi. When many calculi exist together in the bladder, they are usually smoothed and faceted by mutual attrition.

Stones vary greatly in size and consistency. Very large concretions were much more common formerly than now, when they come earlier to operation.

Phosphatic stones are usually soft and friable, though they may sometimes have considerable hardness. Uric acid makes firmer calculi, which are, however, tolerably brittle. The hardest stones are those made of oxalate of lime, and they may occasionally resist any but the most powerful lithotrites.

Stone in the bladder is often hereditary. A gouty or rheumatic diathesis, by favoring the production of acid urine, fosters the tendency to stone.

The habitual use of liquids or articles of food that easily ferment and give rise to acidity may increase the chances to stone formation. That the quality of the drinking water (presence of lime salts) has any influence, is not proved.

The geographical distribution of stone seems to be independent of any climatic or geologic influences.

Dr. Keyes believes that the prevalence of stone in certain localities is to be in great measure accounted for by the hereditary nature of calculous disease, fostered by more or less close intermarriage.

Thompson states that stone is common in the children of the poor, but rare among old persons; whereas among the rich this state of things is reversed and the children are exempt, while their elders are oftener afflicted.

Symptoms.—The symptoms of stone in the bladder are: First, pain. This is especially severe at the end of micturition, when the bladder wall closes down upon the rough surface of the calculus. The pain is referred either to the end of the penis, or to the perineum and

* From author's article in Morrow's "System of Genito-Urinary Diseases, Syphilology, and Dermatology," vol. I.

rectum. It is usually much increased by violent movements or jolting, as in riding. Secondly, *frequency of micturition*, which may or may not be diminished by rest in bed. Thirdly, *hæmaturia*. The presence of blood in the urine is intermittent. The water may be of a wine-red or smoky color, or the blood may be contained in the last few drops of urine passed. Hemorrhage is likely to appear after exercise or jolting. When these important symptoms are present, inquiry will often discover a history of previous attacks of renal colic, or of the appearance of gravel in the urine.

As confirmatory symptoms may be mentioned, sudden stoppage of the stream in the midst of micturition, caused by the stone falling against the urethral opening, and in children an elongated prepuce, owing to constant pulling in the effort to relieve pain felt at the head of the penis.

A bimanual examination between the hand over the pubes and the finger in the rectum will often reveal the presence of a stone of any size.

The diagnosis is rendered complete by a thorough exploration of the bladder with a sound. For this purpose a metallic instrument should be used, with a short beak curved to an angle of about 135°, which, by allowing freedom of motion in the bladder, makes a much more thorough examination possible than with an ordinary curved catheter. Sometimes a stone that evades the sound may be caught with the lithotrite and its presence thus demonstrated. The lithotrite also affords the most accurate method of determining the size of a stone; and by dropping it and seizing it again several times the dimensions may be measured in several diameters. When a stone is caught in the lithotrite, it should be firmly held and the instrument with the stone in it should then be used for a further search, to determine whether more than one stone be present.

It is well during an exploration, especially in a difficult case, to vary the amount of water in the bladder, as a concretion, difficult of detection in a full bladder, may be easily found in an empty one, and *vice versâ*.

Occasionally it happens that in a sacculated or otherwise misshappen bladder a calculus will evade detection by most thorough and skilful sounding. For these cases Professor Bigelow has pointed out the value of the litholapaxy pump and tube. The current of water searches out and brings the calculus to the tube with a characteristic click which cannot be mistaken or overlooked.

Examination by the sound may be rendered difficult by stricture of the urethra, which if not passable for an instrument of fair size will require dilatation, divulsion, or urethrotomy.

Enlarged prostate may greatly increase the difficulties of sounding, both by the resistance it offers to the entrance of the instrument and by reason of the sacculation of the bladder behind the prostate in which the stone may escape detection. This source of error is usually to be avoided if a sound with a short beak be used and so rotated that the point sweeps the base of the bladder. To accomplish this manœuvre the handle of the sound or searcher must be well depressed between the thighs, as otherwise its point catches on the floor of the bladder. The finger in the rectum may materially assist in this investigation. A bar at the internal urethral orifice may cause difficulties similar to those incident to an enlarged prostate.

Sacs and diverticula of the bladder occasionally make the detection of a stone by the sound alone very difficult, though often a careful search will finally carry the instrument into contact with some part of the calculus.

Extreme sensitiveness will often make an examination impossible without the aid of an anæsthetic.

The sources of error which must be considered in sounding are prostatic concretions, rough projections of the bladder wall, which may be covered with phosphatic deposits, and new growths which may be similarly incrusted.

A practised touch will usually lead to a decision between these conditions. The grating over a prostatic concretion is felt before the bladder is reached, and in a case in which the doubtful sensation is felt within the bladder, a conclusion may usually be reached by the passage of a lithotrite and grasping of the stone if one exists.

Prophylaxis.—Soft phosphatic stones are, as has been said, dependent usually upon a local condition of inflammation of the bladder, and any treatment, by irrigation or otherwise, which reduces this inflammation lessens the chances of stone formation. Uric acid and oxalate of lime stones, on the other hand, are of constitutional origin, and indicate faults of assimilation and tissue change which are in a degree amenable to constitutional treatment.

When a tendency to uric acid formation is evinced by the appearance of crystals in the urine, or by any symptoms indicating a gouty diathesis, efforts should be made to counteract this tendency by strict attention to the patient's habits with regard to food and exercise. Sugar in every form is harmful in these cases, as are also all fatty articles of food, and these should accordingly be avoided. Over-indulgence in stimulating, highly seasoned dishes should be interdicted. Wine should be given up, and if the stimulant effect is needed, spirits, largely diluted, should be preferred. Systematic exercise should be taken—if possible, sufficiently violent to excite moderate perspiration, and the skin should be cared for by regular bathing and vigorous rubbing. If the patient be constipated, his bowels should be regulated, and this may well be done by a morning glass of Friedrichshall or Carlsbad water. Thompson recommends a long course of saline waters for these patients with uric acid tendencies, and regards their effect as due to a stimulant action on the liver. Whatever the *rationale* of their use, they are of undoubted benefit when a constipated habit exists.

Lastly, general tonics, such as strychnine and quinine, may be of great service when the general health is debilitated. Alkaline diuretics, by correcting the over-acidity of the urine, relieve local symptoms; but without the addition of general treatment the acidity returns quickly upon their disuse.

Treatment.—After the formation of a stone too large to pass through the urethra, its removal can be accomplished only by some mechanical expedient. The solvent action of alkaline or other remedies has never been shown to destroy a stone that had been proved to exist.

The choice of the operation appropriate to each case is to be decided both by the character of the stone and by the condition of the urinary organs.

Children stand the operation of litholapaxy very well. Occasionally the small size of the urethra makes this operation impossible, but, except in these cases, it is to be preferred to lithotomy.

The crushing of stone—lithotrity—became a recognized operation in 1824 through the efforts of Civiale, who, although operating with inferior instruments, obtained successes which demonstrated the possibility of pulverizing stones with instruments introduced through the urethra.

After that time the operation was greatly improved in technique, and largely displaced the earlier operation of lithotomy. (For the history of its development, see under the head of *Lithotrity*.)

In 1879 Prof. Henry J. Bigelow published a paper introducing the operation of litholapaxy (lithotrity at one sitting, rapid lithotrity), and so quickly did this procedure gain in favor that within a year or two of the publication of his first article it was a generally established practice; and the old operation of lithotrity, without complete evacuation, had become a thing of the past.

Professor Bigelow showed that the tolerance of the bladder to instrumentation is much greater than had been supposed, and demonstrated the fact that there is less danger in an operation, even long and tedious, which results in the complete evacuation of a stone, than in the usual short and repeated sittings for its more gradual removal. In short, he proved that the greatest danger of lithotrity is not from the use of instruments, but from the subsequent irritation of the mucous membrane by

the fragments left in the bladder. To facilitate the rapid crushing and removal of stones, he also introduced improved instruments, which will be described under the head of *Litholapaxy.*

With these instruments it is now possible to dispose of many stones that would formerly have been thought beyond the reach of lithotrity, and it suffices to say that litholapaxy should be employed in all stone patients, except in cases falling under the following exceptions:

1. A very large and hard stone may resist every attempt at crushing.
2. A stone may have as a nucleus a foreign body, such as a piece of necrosed bone or a bullet, too hard to crush and too large to come through a tube.
3. An encysted stone may be out of reach of the lithotrite.
4. Some writers consider that stricture of the urethra may prohibit litholapaxy. This cannot often happen, for strictures, however close, yield readily to divulsion, which may be immediately followed by the crushing and evacuation of the stone. We have so often seen these two operations successfully done together upon an etherized patient that we cannot but think this the best practice. While it economizes time, it saves the patient much needless manipulation. When an impassable stricture exists, perineal section followed by perineal lithotrity must be done.
5. The small size of the urethra in children may prevent the passage of instruments.
6. Hypertrophy of the prostate may occasionally render the passage of the lithotrite impossible and render lithotomy necessary.
7. False passages may exist, which so interfere with the introduction of instruments that the dangers of the operation are greatly enhanced, and the question of lithotomy is to be entertained.
8. The hip may be anchylosed in a position which interferes with the use of instruments.

In any of these exceptional cases, a cutting operation may be required, and a consideration of the various methods of performing such operations will be found under the head of *Lithotomy.*

Arthur T. Cabot.
Hugh Cabot.

BLADDER-WRACK.—*Sea-wrack. Kelp-ware. Black-tang.* The plant *Fucus vesiculosus* L. (fam. *Fucaceæ*). This peculiar coarse sea-weed grows in the greatest abundance on the rocky Atlantic shores of both this country and Europe. At low tide it covers the rocks thickly with its prostrate greenish-yellow fronds, while, when the tide is full and the plant is enabled to float by the aid of its numerous air vesicles or "bladders," it covers the bottom with a forest of weeds. This is one of the plants which have been most extensively employed in the manufacture of kelp. It has also been considerably used in medicine as a deobstruent and alterative. Neither its composition nor its properties have been made well known, and its value is problematical. It contains one-fifth per cent. or more of iodine, in combination with potash. Rarely, considerable quantities of tannin have been observed in it. It has been loudly proclaimed as an agent to reduce obesity, and proprietary articles sold for this purpose are said to contain it. The dose is 2 to 15 gm. (ʒ ss. to iv.). Most manufacturing houses prepare both fluid and solid extracts. The dose of the latter is 0.3 to 2 gm. (gr. v. to xxx.).

H. H. Rusby.

BLADON SPRINGS.—Choctaw County, Alabama.

POST-OFFICE.—Bladon Springs. Hotel and cottages.

ACCESS.—Viâ Mobile and Birmingham Railroad to Carson Station, thence twenty-nine miles by hack to springs; also, by Mobile and Ohio Railroad to Buckatunna, Miss., thence twenty-eight miles by stage or hack; also by steamer from Mobile, Tuesday and Saturday service. There is also a bi-weekly south-bound steamer service from Demopolis. The springs are four miles from the steamer landing on the Tombigbee River.

For upward of thirty years the Bladon Springs have been a favorite resort for the best people of Alabama and the neighboring Gulf States. The steady influx of visitors of late years renders it necessary to keep the hotel open all the year.

The location is about eighty miles from the Gulf as the crow flies, and about one hundred and seventy feet above tide water. The climate is mild and equable, the mean annual temperature being 75° F. The nights are delightfully cool, averaging about 65° F. after eight o'clock during July and August. The surrounding country is hilly and heavily wooded with pines, and excellently adapted for thorough drainage. The resort offers abundant inducement for those wishing to escape the rigors of a Northern winter. Game is abundant during the fall and winter months, and it is said that deer are killed within a mile of the hotel.

We are indebted to Dr. Showalter, of the Springs, for the following analyses:

ONE UNITED STATES GALLON CONTAINS:

Solids.	Vichy Spring. J. L & W. P. Riddell. Grains.	Branch Spring. J. L. & W. P. Riddell. Grains.	Sulphur Spring. J. L. & W. P. Riddell. Grains.	Old Spring. R. P. Brumby. Grains.
Sodium carbonate	46.33	41.21	34.93	32.89
Magnesium "	.29	.61	.65	1.36
Calcium "	.87	2.14	2.42	2.75
Iron "	.49	.23	.76	.02
Calcium sulphate	2.25	2.79	2.96	....
Iron	....	....	....	.24
Sodium chloride	....	....	....	7.69
Strontium	....	....	....	.32
Silica	....	....	....	2.10
Organic matter	2.26	1.90	1.25	...
Crenic acid	....	....	....	.75
Hypocrenic acid	....	....	....	.60
Total	52.49	48.88	42.97	48.72

Gases.	Cubic inch.	Cubic inch.	Cubic inch.	Cubic inch.
Carbonic acid	65.44	59.20	52.88	32.56
Sulphureted hydrogen	....	....	.56	....
Chlorine	1.84	1.84	1.84	....
Total	67.28	61.04	55.28	32.56

The waters are of the alkaline type, quite plentifully charged with carbonic acid. They are useful in chronic indigestion, in syphilitic cachexia, in advanced nephritis, in diabetes mellitus, and in rheumatism.

James K. Crook.

END OF VOLUME I.